SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JUNE 1923.

GENERAL PHYSICS.

793. *Density Determinations of Metals and Alloys, Solid and Liquid. IV. Buoyancy Method. Systems Sb-Zn, Al-Sb, Ag, Mg.* **F. Sauerwald.** (Zeits. f. Metallkunde, 14. pp. 457–461, Dec., 1922.)—Continuation of the experiments [Abstract 2021 (1922) and 104 (1923)] also on technically unimportant alloys. The Sb-Zn alloys, when solid, have a higher specific volume than corresponds to their composition; this holds also for the liquid alloys, when probably only the compound Zn_3Sb_2 persists though also dissociated; the curves differ from those of Maey. The solid Al-Sb alloys likewise show a higher specific volume than would be expected, but this does not hold for the liquid; metal is forced out of the solidifying alloy. The compound (?) AlSb contracts in melting, probably because it dissociates; a new diagram of state is therefore proposed for Al-Sb; the two metals may not be perfectly miscible. Silver contracts by 1·56 per cent. between 1100° and 961°, and by 3·67 per cent. between 961° and 18°; at solidification the specific volume is 0·1073 liquid and 0·1033 solid. For the experiments with strongly-reducing metals like magnesium, crucibles of magnesia (instead of quartz) were tried; but they became heavier in the NaCl-KCl bath. The value 0·647 for the specific volume of magnesium at 780° is hence uncertain. H. B.

794. *Laws of Failure of Solid Bodies due to Stress.* **C. Sunatani.** (Tôhoku Univ., Technol. Reports, 3. 1. pp. 1–56, 1922. In English.)—The object of this investigation was to determine the laws by which the elastic limit and ultimate failure of a solid body under a certain state of stress may be determined. The author, from an observation of simple facts governing the failures of solid bodies, has proposed two laws, from which the elastic limit and point of ultimate failure of a body under any stress may be determined. An account is given of the various theories for the failure of solid bodies, and also a description of experiments made by the author. The theoretical side of the subject is discussed in connection with the results of the tests and the following conclusions arrived at: (1) None of the previous theories advanced is true and Mohr's theory cannot be a general law of failure of a solid body,

(2) There are two kinds of starting failure, *i.e.* sliding and tensile separations, and two simple laws, which the author for the first time proposes, namely (*a*) true shearing strength increases or decreases proportional to the normal component of stress, as it is tensile or compressive, and may be expressed by the equation $Rs = Rs_0 - k \, . \, N$, where Rs is the shearing strength per unit area of a plane on which there exists a certain amount of normal component stress N Rs_0 is the same quantity when there is *no* normal component, and k, a coefficient; and (*b*) true tensile strength decreases proportionate to the tangential component of stress, and may be a similar form of equation in terms of tensile strength. In both cases, the proportional constant k is about 0·364, or ϕ about 20°. (3) In an isotropic body there occurs a sliding failure, or a tensile one, according as $\frac{1}{2 \cos \phi}\left\{T_1 - T_3 + (T_1 + T_3) \sin \phi\right\}$ or $\frac{1}{2 \cos \phi}\left\{T_1 - T_3 + (T_1 + T_3) \cos \phi\right\}$ is greater than Rs_0 or Rt_0 respectively, where T_1 and T_3 are the maximum and minimum principal stresses. The normal of the plane of failure lies in the plane perpendicular to the middle principal stress T_2, and makes an angle of $\left(\frac{\pi}{4} - \frac{\phi}{2}\right)$ or $\frac{\phi}{2}$ with the maximum principal stress, according as it is a sliding or a tensile one, so that the elastic or breaking stress can be anticipated when the value of Rs_0 or Rt_0 of the material is known. The above statements refer to both elastic and ultimate failures for ductile or brittle materials. The paper is well illustrated with diagrams and photographs. A. W. J.

795. *Elastic After-Effect and Elastic Hysteresis.* **J. Ôkubo.** (Tôhoku Univ., Sci. Reports, 11. pp. 173–182, June, 1922. In English.)—If a metal, composed of an aggregate of minute crystals, is deformed beyond its elastic limit by stretching or twisting, a slipping in each crystal along the plane of cleavage occurs. In virtue of friction acting between the slipping planes the displacement occurs gradually, but not simultaneously, with the application of the stretching force, thus giving the phenomena of elastic after-effect and hysteresis. The author gives a mathematical calculation of the effects assuming, for simplicity, that the number of slipping surfaces and the frictional coefficient are constant. The case of a metallic rod is first considered, supposing a periodic displacement to be given to one end. The equation of motion of an infinitesimal layer is written down by equating the mass-acceleration of an element to the resultant of the frictional forces (proportional to velocity of slip) acting upon it. Solving this under the appropriate conditions, the displacement of any point along the rod is found. Other cases are discussed: (*a*) the twisting of a thin circular tube by a couple applied to one end, (*b*) a torsional couple applied to the outer surface of a solid cylinder, (*c*) a torsional couple applied at the surface of a hollow cylinder cut in an infinitely extended solid. For the rod it is shown that the stretching displacement applied at the extremity of the specimen is propagated with a velocity $\sqrt{2p\rho/\mu}$, and that the amplitude at a point distant l along the rod is diminished in the ratio $e^{-\sqrt{\frac{p\rho}{\mu}}(l-l_0)}$ where l_0 is the length of the rod, ρ the density and μ the frictional coefficient of the material of the rod, and p the period of the displacement at the end. Plotting the displacement at any point against the displacement at the end (or the load) the hysteresis curve is obtained.

On withdrawing all the load the state of the material is not the initial state. E. Hayn supposes that the slip-planes are in a state of semi-equilibrium tending to return to their initial positions and therefore if a stretching force be again applied in the direction of the first application the planes will not displace until the load exceeds some definite value. Hence, to a material previously strained beyond its yielding-point a stretching force greater than the initial must be applied to give the same displacement. In this way the phenomena of "strengthening by stretching" may be explained. T. H.

796. *Air Resistance of Circular Plates in a Stream Perpendicular to their Surfaces.* **H. Zickendraht.** (Zeits. f. Physik, 12. 3 and 4. pp. 232–242, 1922.)—The "resistance number" C is equal to 100 W/hF, where W is the air resistance measured by a dynamometer attached to the plate, in kg. per sq. m., F the area of the plate in sq. m., and h the excess air pressure at the middle of the plate (1 mm. water column per sq. cm. = 1 kg. per sq. m.). This was determined for plates 100, 50, 25, 12·5, and 6·25 sq. cm. in area, for air velocities between 2 and 7 metres per second. The plate was not damped in any way, as it was found that the study of its to and fro movements led to valuable results. Measurements were taken at the positions where the plate placed itself most frequently, and remained steady the longest. When the results are plotted it is seen that they do not lie along smooth curves; but it is clear that the resistance number varies with the air velocity, each of the smaller plates showing a minimum value of C for a definite wind velocity. C depends on the diameter. A vortex ring is formed at the edge of the disc on the lee side; this can be photographed by the method previously described by the author (Ann. d. Physik, 35. p. 73, 1912). This vortex ring is in an unstable state, and breaks up every now and then, disturbing the symmetry of the aerodynamical field; a new ring is then formed and the action is repeated. At a certain distance behind the plate (on the lee side) there is a region of increased pressure, from which air flows along the axis in both directions; this "forward current" passes axially through the vortex ring, and strikes on the back of the plate; it dies out when the vortex ring breaks, and causes irregularities in the dynamometer readings. This action depends largely on the regularity of the stream on the weather side; and experiments were made in which it was made gusty by allowing a flat piece of wood hung as a pendulum to move to and fro across it (about 8 vibrations per second); the effect was to increase C from 109·3 to 138·3, with wind velocity 4·9 m. per sec., and from 120·5 to 130·8, with 6·8 m. per sec. The plates themselves produce gustiness, and this increases with the velocity. Taking these considerations into account, the results observed can be explained on the assumption that the resistance number increases with the diameter, though this does not appear directly from the experiments with the two largest discs, which were too large for the air stream employed.

H. N. A.

797. *Experiments on the Flow of Fluids in Tubes.* **C. Schaefer** and **G. Heisen.** (Zeits. f. Physik, 12. 3 and 4. pp. 165–176, 1922.)—The time of flow of a definite volume of chloroform through a capillary tube, under different pressure heads, and at different temperatures was measured, the variations of density and viscosity with temperature for this liquid having been carefully determined. The index n in the formula $p = Ct^{-n}$ was determined for various ranges of p, being 1 for small heads, 1·495 at greater heads, and 1·930 in the region of turbulence. C is a function of viscosity and density, as well as of the dimensions of the apparatus, and the main point of the experiments is a test of its dependence on the first two as shown by its variation with temperature. Observed and calculated variations agree to within 1 %.

Effects of lack of homogeneity in the fluid in inducing turbulence were also sought by experiments with a 3 % solution of hæmoglobin, 10 % colloidal silver, and a suspension of small particles of amber in salt solution, but though the diameter of some of the latter particles was nearly as great as that of the tube, no effect was observable. W. G. B.

798. *Glue Bubbles and Pressure Therein.* **C. Barus.** (Science, 57, pp. 151–153, Feb. 2, 1923.)—The interferometer **U**-gauge previously described has been applied to determine the excess pressure in the interior of bubbles of sugar solutions, molasses, and glue, the bubble in each case passing, by evaporation, from the liquid to the solid state. The surface tension of the film is deduced from the measured excess pressure, and its variation with time plotted. In the case of glue bubbles, the surface tension initially increases, at first slowly and then rapidly, until a maximum value is attained. The surface tension remains constant at this value for an interval of some minutes until the bubble is practically solid. Thereafter, gas leaks through the bubble and the value of the surface tension *apparently* decreases. The surface tension of a solution of glue is low and constant (about 25 c.g.s. units) until a dilution of the order 0·005 is reached. On further diluting the solution, the surface tension increases very rapidly, the value for a concentration 0·001 being approximately 60 c.g.s. units. J. S. G. T.

799. *Coefficient of Normal Viscosity in Metals.* **K. Honda** and **S. Konno.** (Tôhoku Univ., Sci. Reports, 11. pp. 435–445, Nov., 1922. Sixty-eighth Report from Research Inst. for Iron and Steel and other Metals. In English.)—The coefficients of normal viscosity of 12 different metals were measured at room temperatures. Values range from $0 \cdot 7 \times 10^8$ to 27×10^8. The latter figure is for zinc, which, having a low melting-point, has a high coefficient of viscosity. The coefficients of normal and tangential viscosities are of the same order of magnitude. Annealing causes a decrease in the value of the coefficient of viscosity. In carbon steels the coefficient increases with carbon content. [See Abstract 1517 (1921).] J. L. H.

800. *Sub-Synchronous Pendulums.* **D. Banerji.** (Indian Assoc. for Cultivation of Science, Proc. 7. 3. and 4. pp. 145–158, 1922.)—The maintained oscillations of a sub-synchronous pendulum noticed by Rayleigh and later by Dey and by C. V. Raman, have now been studied with a 35-cm. iron bar pendulum and an interrupter fork of 32 per sec. The exact equality of the *ratio* of frequency of maintenance of the pendulum to that of the fork to one or other of the "frequency ratios" for slight variations in temperature was established by chronographic records for the fork. Maintenance of the sub-synchronous pendulum may be obtained at two or three different amplitudes, but maintenance is not possible for very large and for very small amplitudes. A method has been developed for determining by photographic record the phase of passage of the pendulum through its equilibrium position in relation to the periodic magnetic field. The phase-angle is almost zero for small amplitudes and $\pi/2$ for very large ones. A theory of the maintenance is developed and, where tested, shows a fair agreement [see Abstract 1419 (1919)]. E. H. B.

801. *Electrical Timing Device for Short Intervals.* **D. Robertson** and **N. F. Frome.** (Inst. El. Eng., J. 61. pp. 49–51, Dec., 1922.)—The timing device described consists of a Wheatstone bridge with three non-inductive arms and one highly inductive arm. Owing to the inductance of the latter, the initial current through the galvanometer branch of the bridge is in the opposite direction from the steady current through this arm. Hence, if a polarised relay be used in place of the galvanometer, the first current will deflect the tongue against one stop and the second current will deflect it against the other stop. The time interval between the switching-on of current to the bridge and the reversal of current in the relay branch varies with the electrical constants of the bridge and with the position of the contact on the slide-wire. The relay can be made to close or open an electrical circuit for a definite interval of time, and this secondary circuit can be used to control any desired operation. By adding other relays connected to different points on the slide-wire, several operations can be obtained in a definite timed sequence. Complete data concerning the bridge used by the authors are given in the paper and the theory of the circuit is developed. Owing to various disturbing causes, the actual curve between bridge reading and duration of contact differs considerably from the calculated curve. The device must be calibrated experimentally and the reading obtained for a given position of the slider varies greatly with the adjustment of the relay. On the other hand, for any one setting of the relay the readings can be repeated indefinitely with good accuracy over a wide range. Also, after altering the setting of the relay, it is possible to return to the initial calibration by adjusting the relay to give the same deflection as before at some one point on the scale. R. E. N.

802. *Numerical Calculation of the Processes in Moderately Rarefied Gases.* **D. Enskog.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 16. 16. pp. 1–60, 1922.)—In an earlier paper, "Kinetic Theory of the Processes in Moderately Rarefied Gases" (Inaugural dissertation, Upsala, 1917), the author has developed the kinetic theory of conduction, viscosity, and diffusion, and has given the values of the coefficients as infinite series.

The separate terms of these series can be calculated with different hypotheses for the molecular forces. The present paper gives the investigation of the necessary equations and approximations. It is necessarily of an intricate mathematical nature, and cannot be usefully abstracted.

The results are compared with those of Chapman [see Abstracts 794 (1916) and 970 (1917)], and it is found that there is agreement in the values of the coefficients of viscosity and conduction for a simple gas, but errors are pointed out in some other cases in Chapman's calculations. T. B.

803. *A Technical High Vacuum Mercury Vapour Pump.* **H. Stintzing.** (Zeits. techn. Physik. 3. 12. pp. 369–377, 1922.)—According to Gehrts a high vacuum pump is one which attains a pressure of 10^{-7} mm. Hg, and he gives [see Abstract 338 (1921)] as characteristics for such pumps: (1) The requisite pre-vacuum pressure; (2) the attainable end vacuum; (3) the suction velocity. These points are first considered in detail in the present paper, following which comes the illustrated description of a new mercury vapour pump constructed of steel. The qualitative service rendered is, like that of other mercury pumps, limited by the vapour pressure of mercury, but in contrast to the diffusion-pump mercury vapour can be also sucked away. The quantitative service, however, is much greater in consequence of the unlimited possibility of increase to the cross-section employed. The new pump when working normally offers considerable resistance towards external temperature influence. In principle it is a combination of expansion and condensation effects and in some respects is like the Crawford high vacuum pump [see Abstract 128 (1918)]. The pump can easily be manipulated and cleansed, while it is capable of employment for vapours of fats, oils, salts, acids, and metals. Every pre-vacuum between 1 mm. Hg and that of the best oil vacuum pumps is applicable. The pump may be heated by gas or electricity without alteration of its construction, and its vapour pressure is registered and may be regulated by a scale. The heating of the pump can be accelerated to about 1/10th the period of that necessary for glass pumps, and the pump may be opened when in a hot condition in contrast to the cooling period required for the former, while much less danger attends negligence as also its hygienic behaviour. Details of the pump and its mode of working are very fully described. H. H. Ho.

804. *A Hydrodynamical Problem.* I. **C. W. Oseen.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 17. 4. pp. 1–37, 1922.)—Mainly mathematical. A general solution of the differential equations of viscous fluid flow, modified in a well-known manner originally due to the author, by which the "inertia" terms are partially taken into account, is obtained for two-dimensional flow on one side of an infinite plane, when the velocity is specified on that plane. The solution involves a set of three functions, analogous to Green's functions, and is a definite integral taken along the axis. The flow past a cylinder is also considered, and it appears that the functions change in form according as the angle between the normal and the direction of flow is greater or less than 90°. A set of integral equations to determine these functions is given. W. G. B.

805. *Mechanical and Electro-Mechanical Oscillations.* **H. Schieferstein.** (Zeits. techn. Physik. 3. 12. pp. 377–380, 1922. Extract from lecture read before the Deut. Naturforscher u. Ärzte, Leipzig, Sept., 1922.)—Oscillatory mechanism generally works less efficiently than rotatory, and the present paper describes ways and means for improving such mechanism to a degree of equality at least. Experiments are detailed and a series of machines and apparatus employing oscillatory movements are discussed. The example of an oscillating surface unfolds the possibility of introducing such mechanism into the technique of flying machines. Eleven diagrams are included to show different applications of the ideas involved. H. H. Ho.

806. *Reflection and Permanence of Stellite Mirrors.* **C. G. Abbot, F. E. Fowle,** and **L. B. Aldrich.** (Smithsonian Inst. Astrophys. Obs., Annals, 4. pp. 86–87, 1922.)—Stellite, an alloy of chromium, cobalt, and tungsten, is investigated both with regard to its permanence and its reflecting power. It is extremely resistent to atmospheric corrosion, the polish being restored by rubbing with wool after months of exposure to city air and rain. The reflecting power is similar to speculum metal and has an advantage over silver in that it has no transparent band in the ultra-violet. Tables of reflecting power and wave-length are given. A. Wh.

807. *Regularity of Pyrheliometer.* **C. G. Abbot, F. E. Fowle,** and **L. B. Aldrich.** (Smithsonian Inst. Astrophys. Obs., Annals, 4. pp. 89–97, 1922.)—A tabulated series of comparisons between several pyrheliometers to demonstrate their reliability as standard measuring instruments of radiation. A. Wh.

808. *High-Speed Photography of Vibrations.* **A. Trowbridge.** (Frank. Inst., J. 194. pp. 713–729, Dec., 1922.)—In claiming that photographic recording is the quickest, cheapest, simplest, and cleanest of all methods of recording sound, mechanical or electrical vibrations, the author points to its successful use in sound ranging under very unsuitable conditions during the war. To adapt the field camera for laboratory purposes, its design was modified to allow film exposure rates up to 4 ft. per sec. In its essential features the camera resembles the moving-picture camera, but the shutter is dispensed with and a continuous record of the motion is obtained. The motion of a spot of light or of a shadow is recorded directly, but when the motion is transmitted electrically to the camera, a string galvanometer is employed to give a synchronous motion. When the sensitised tape is started, it begins at once to be fed into the developing bath, but more slowly than it is being exposed; a roller transfers the developed film into the fixing bath, and a knife cuts the tape when the exposure is finished. A foot switch starts the motor which drives the mechanism, different speeds being obtainable by gears. The time scale is recorded on the tape by means of a phonic wheel, or spoked wheel, whose rotation is controlled by an electrically driven tuning fork; the shadow of a spoke is thrown on the sensitive tape every hundredth of a second. The examples given of the use of the instrument include that of an oscillograph for current and voltage waves; a recorder of telephone current variations caused by sounding musical notes near the microphone; and as a recorder of pressure and volume changes in the cylinders of high-speed internal combustion engines. An indicator is described which gives the time-rate of change of pressure in the cylinder; the record obtained is stated to have advantages over the ordinary indicator diagram. The paper is illustrated by photographic records of electrical and sound vibrations. [See also Abstract 1451 (1903).] G. E. A.

809. *Experiments in an Aeroplane with the Pulfrich Clinometer.* **K. Wegener** and **K. Schneider.** (Phys. Zeits. 23. pp. 543–544, Dec. 15, 1922.)—The Pulfrich clinometer reflects the horizon from two opposite directions in the field of a telescope. One of the reflecting prisms is rotatory. It is rotated until the two horizons overlap. The reading of the rotation gives double the dip of the horizon. From a position in the air above a sharply defined layer of vapour a vapour horizon is clearly visible whose height above sea-level can be determined from the dip and from the barometric indication of the height of the aeroplane. At a small height above the vapour horizon the observer is placed as if in a small vessel on a rough sea. The horizon is not clearly visible, being blurred by irregular streaks of mist. At a great height above the vapour surface the slight opacity of the upper layer is interposed between the eye and the distant horizon. The most favourable position is about 300 m. above the vapour surface. It was found that the vapour surface did not coincide with the lowest temperature of the vaporous layer, but extended beyond it when the lowest temperature formed a sliding surface between the dense lower and the rarefied upper layer. Rapid, approximately vertical atmospheric oscillations occur in the turbulent part of the upper layer, which probably represent incipient cloud formation and proceed from the friction on the sliding surface. For aviation purposes the range of the instrument is too limited (± 13′, corresponding to a height of about 80 m. above the horizon). Measurements from a height of at least 1000–2000 m. are necessary. The difference in brightness between the sky and the vapour layer is generally very slight. If the image of the opposite horizon be pushed over the other, the boundary often disappears and no adjustment can be made. The best position for an observation is perpendicular to the direction of the sun's rays, and it is better to place the images of the two horizons side by side so that one forms a continuation of the other. E. F.

810. *Propagation of Gravitation Waves.* **A. S. Eddington.** (Roy. Soc., Proc. 102. pp. 268–282, Dec. 1, 1922.)—Einstein's analysis shows how the coordinates must be chosen if it is desired to represent the gravitational potential as propagated with the speed of light. But the propagation of the actual physical condition—the altered curvature of space-time—has not hitherto been discussed. Weyl classifies plane gravitational waves into three types: transverse-transverse, transverse-longitudinal, and longitudinal-longitudinal. The present analysis shows that the first type is propagated with the speed of light in all systems of coordinates—whereas waves of the other types have no fixed velocity, a result which rouses suspicion as to their objective existence. The only case in which Weyl's three types of waves exist independently is in that of plane waves—but plane waves are a special and artificial case, and the usual case of divergent waves is given special treatment in the later part of the present paper.

On considering the Riemann-Christoffel tensor and the Einstein tensor for plane waves it is found that the former tensor depends solely on the transverse-transverse waves. It is also found that a suitable source of such waves is a periodic stress alternating between two directions at right angles to the path, which is equivalent to circular motion of a plate in its own plane. It seems remarkable that the only genuine gravitational waves arise from secondary disturbances in the distribution of matter, but we must remember that a backward and forward motion of an *infinite* plate causes no disturbance in the field.

In the investigation of divergent waves, a solution of the tensor is $h_{\mu\nu} = \frac{A_{\mu\nu}}{2\pi} \cdot \frac{e^{ip(t-r)}}{r}$ in agreement with the usual formula for spherical waves in sound and electromagnetism. But this solution does not satisfy the law of gravitation, an unexpected result. So the conclusion is forced that there cannot be a simple source of gravitational waves. The author calculates the complete solution for a rod spinning in the plane *yz*, and finds the residual radiation resulting. As an example, the radiation from a rod 2 m. long, 1 kgm. mass, is a loss of $3 \cdot 1 \times 10^{-35}$ of its energy of rotation in a year, when it makes 50 revolutions per second.
P. E. S.

811. *Physical Interpretation of Complex Angles and their Functions.* **A. Boyajian.** (Am. I.E.E., J. 42. pp. 155–164, Feb., 1923.)—The object of this article is to explain a way of regarding angular measure which leads to a satisfactory physical interpretation of the properties of the so-called "imaginary" and "complex" angles arising in many engineering problems. In principle the method is based on the idea of percentage or proportional change in a quantity. If a quantity change by a certain compound percentage, that percentage is the "angular" change in the quantity. All idea of corner, or edge, or of rotation, are thus eliminated from this general conception. If the percentage change in the quantity is geometrically parallel to the quantity itself the change is called the "hyperbolic angle" and there is no rotation. If the change is one of direction only, and is perpendicular to the quantity, the angle is "circular" and there is rotation. Thus hyperbolic and circular angles are in quadrature, the first being per cent. change parallel to and the second perpendicular to the quantity. This new idea is in agreement with the general representation of the arcs of curves. If a radius vector trace with its extremity the arc of a curve, the two components of the arc along and perpendicular to the vector respectively, expressed as a fraction of the radius vector, represent the hyperbolic and circular angles subtended by the arc; their sum is the complex angle of the arc. The choice of names for these quantities is unfortunate; it would be better if the ordinary circular angle were called the "quadrature" angle, and the hyperbolic angle were renamed the "linear" or "radial" angle of the change. The new interpretation is thus essentially vectorial, and is used to explain the physical significance of the sines and cosines of circular and hyperbolic angles. A geometrical construction for the sines and cosines of complex angles is given, the theory being illustrated with reference to such practical problems as the resolution of a harmonic wave into two oppositely rotating waves, the solution of differential equations, etc.
B. H.

812. *Notes on the Quantelation of Unconditioned Periodic Systems.* **A. Smekal.** (Zeits. f. Physik, 11. 4 and 5. pp. 294–303, 1922.)—Recent work on this subject by Epstein, Born and Pauli, and Bohr [see Abstract 1886 (1922)] is first discussed. It is then shown that if the Ehrenfest adiabatic requirements and the Bohr correspondence principle be accepted, the quanta theoretical solutions of the equations of motion of unconditioned periodic mechanical systems of f degrees of freedom cannot, as a rule, be obtained as general solutions. If, however, conditioned periodic particular solutions of s independent periods be chosen, then the above requirements are found to be satisfied and the conclusion $s < f$ found in agreement with experience. By this method a fundamental quantum process is obtained for application to pure atomic problems. The results are regarded by the author as a basis for a quantum treatment of reciprocal molecular effects, especially with respect to translation and inclusive of impact. H. H. Ho.

813. *Polar and Axial Vectors in Physics.* **F. Emde.** (Zeits. f. Physik, 12. 5. pp. 258–264, 1922.)—It is only possible to distinguish between polar and axial vectors in the case of kinematic vectors, and the distinction between mono-vectors and bi-vectors (space and plan) has a meaning only in geometry. The distinction has no significance in dynamics and in electricity, and nothing is lost in the simplification which results from ignoring it. J. W. T. W.

814. *Structure and Polymorphism of Silica.* **R. B. Sosman.** (Frank. Inst., J. 194. pp. 741–764, Dec., 1922. Paper read before the Am. Chem. Soc., Birmingham, Alabama, April, 1922.)—A full sketch of a theory of the ultimate structure of the various polymorphs. A. D.

815. *Structure of the Atomic Nucleus, and the Variation of Coulomb's Law in its Interior. Lithium and Isohelium.* **M. C. Neuburger.** (Ann. d. Physik, 68. 7 and 8. pp. 574–582, Oct. 4, 1922.)—A. Smekal has considered the variations of Coulomb's law in the immediate neighbourhood of elementary electrical charges, in connection with the nuclei of helium and Rutherford's X_3 (isohelium). The present author has worked out a general nuclear model [Abstract 1737 (1922)], and applies the formulæ obtained to the cases of lithium Li_6 and isohelium. Isohelium is treated again, since its atomic weight has been redetermined since Smekal's investigation. Circular orbits are assumed for the particles which make up the nuclei, as it is not at present necessary to consider the possibility of elliptical orbits, as in the case of the outside electrons. The special nuclear formula for Li_6 is $F_k^{Li_6} = 2a_i + \beta$, where a_i is the nucleus of isohelium (atomic weight 3) and β is the nuclear electron. It may be assumed provisionally that the two a_i particles rotate round the β particle in a ring. The condition for dynamical equilibrium is $\mu v_R{}^2 = e^2 F \rho^2$, and the quantum condition for the impulse moment is $\mu v_R \rho = h/2\pi$, where μ is the mass of the a_i particle, v_R its velocity, and ρ the radius of the ring; hence $\rho = h^2/4\pi^2 e^2 \mu F$. It is shown that, on the author's theory, F for Li_6 is equal to unity. The stability is determined by the formula first used by Bohr, and the model shown to be stable. The value $9 \cdot 62 \times 10^{-13}$ cm. obtained for ρ is, however, far too large, so the effect of altering the law of force so that it varies as e/ρ^a is considered; a table is constructed giving ρ and W, the combined energy, for values of a between $2 \cdot 040$ and $2 \cdot 050$, and it is found that $a = 2 \cdot 045$ gives $W = -3 \cdot 13$ ergs, which agrees well with the energy derived by means of the theory of relativity from the energy-mass relations. Thus the force varies as $e/\rho^{2 \cdot 045}$, $\rho = 2 \cdot 53 \times 10^{-13}$ cm., $v_R = 8 \cdot 31 \times 10^8$ cm./sec., $w = 5 \cdot 23 \times 10^{20}$ and the heat of formation is $4 \cdot 72 \times 10^7$ calories. For isohelium, the nucleus of which (the a_i particle) is $3H^+ + \beta$, $W = -3 \cdot 60$

$\times 10^{-5}$ ergs, $\rho = 1\cdot 45 \times 10^{-13}$ cm., and the heat of formation is $4\cdot 72 \times 10^{8}$ calories. The force varies as $e/\rho^{2\cdot 127}$. The nucleus of a hypothetical B_9, which has not been observed by Aston, proves to be completely unstable. H. N. A.

816. *Structure and Energy Content of the Atomic Nucleus.* **T. Kaluza.** (Phys. Zeits. 23. pp. 474–475; Disc., 475–476, Nov. 15 and Dec. 1, 1922. Paper read at Deut. Physikertag. Leipzig, Sept., 1922.)—Empirical knowledge of the atomic nucleus is hardly sufficient at present for the construction of an atomic nucleus model which can render the service of the Bohr atomic model. The present paper does not contain such an attempt, but proceeds from general considerations of energetics to obtain data which can be referred if not to a separate nucleus at least to a series of such. The nucleus consisting of a collection of positive and negative charged particles contained within an exceedingly small volume is regarded as a series of Coulomb force centres whose potential energy is then derived, but only for the one-dimensional case in order to simplify the difficulties of the spatial problem. The paper is entirely mathematical. A critical discussion follows the paper. H. H. Ho.

817. *The Hypothesis of Constant Atomic Radii.* **R. W. G. Wyckoff.** (Nat. Acad. Sci., Proc. 9. pp. 33–38, Feb., 1923.)—The author considers different methods of approaching the problem of the calculation of atomic radii, and concludes that cæsium dichloro-iodide offers the best starting-point. The distance along a trigonal axis from a cæsium atom, through one of chlorine, to an iodine atom is 6·102Å., while the nearest approach of Cs to I in cæsium iodide is 3·94Å.; this makes the diameter of the Cl atom 2·162Å. and from this initial value radii can be calculated for other atoms in various crystals. The values so calculated, however, do not always agree for different crystals; and two tables are given, one containing crystals in which the observed interatomic distances agree with the calculated; and another, nearly as long, in which this is not true. A rule of constant atomic radii appears to hold true within certain large groups of isomorphous compounds composed of two kinds of atoms; and this may mean that as long as the number and distribution of one kind of atom about the other remain the same the interatomic distances are additive in passing from crystal to crystal. When the atomic environment is changed the atomic distances also vary. H. N. A.

818. *The Structure of Organic Crystals.* **W. H. Bragg.** (Roy. Inst. Gt. Britain [8 pp.], 1922.)—The remarks of the lecturer on *the radius of combination* of an atom are of interest in connection with Wyckoff's paper on atomic radii [see preceding Abstract]. The principle of radii of combination was described by W. L. Bragg [see Abstract 21 (1921)]. The lecturer cites the behaviour of arsenic, antimony, and bismuth. The crystals of these substances are trigonal in form, plainly showing that the properties of each atom are not the same in all directions within the crystal. It may be said that the atom behaves as a metal on one side and like a non-metal on the other. There are two different radii of combination, and the metallic bond is the weak one, the cleavage plane cutting only through such bonds. In valentinite, which is one form of Sb_2O_3, analysis, as far as it has gone, points emphatically to the conclusion that here atoms of antimony are pairing; the bonds between the members of a pair being "non-metallic." This gives an elementary body of a dumb-bell shape, which, when forming part of the crystal structure, causes a deviation from a simple cube. Valentinite is orthorhombic, while the other form of Sb_2O_3 has cubic crystals. H. N. A.

819. *The Gravitation of Systems.* **J. Le Roux.** (Comptes Rendus, 175. pp. 1135–1136, Dec. 4, 1922.)—The author replies to Brillouin's remarks concerning his criticism of Einstein's theory of gravitation, and points out that whereas Brillouin chooses the most general values of the $g_{\mu\nu}$ satisfying Einstein's equations, he himself has selected only those which lead to an actual value of ds^2 in four dimensions. J. S. G. T.

820. *Einstein's Gravitation Theory.* **J. Le Roux.** (Comptes Rendus, 175. pp. 809–811, Nov. 6, and pp. 1395–1397, Dec. 26, 1922.)—(1) The author points out that the equations of motion of a particle, according to Einstein's formulation, $ds^2 = \Sigma g_{ik} dx_i dx_k$, contain only the four coordinates of the particle. There is no interaction with other moving bodies, consequently no perturbations. Neither is there any coordination. Consider, *e.g.*, two points, $P_x(x_1, x_2, x_3, x_4)$, and P_y in the space-time. The equations of movement of each point, with the initial conditions, enable three coordinates of a point to be expressed in terms of the fourth, after which x_1, x_2, x_3, and y_1, y_2, y_3, may be regarded as functions of x_4 and y_4 respectively. The equations establish no relation between x_4 and y_4. The movement of each point depends, therefore, on one variable, and there is no necessary relation between the variables corresponding to different particles. Hence there is no necessary correlation between the points on two geodesics of the same surface. With regard to Mercury's perihelion advance: The secular anomaly is agreed at 574″. Newtonian theory, involving perturbations, satisfactorily accounts for 536″, leaving a residue of 38″ unaccounted for. The Einstein theory, according to Schwarzschild, give a secular anomaly, calculated from ds^2, of 38″, leaving an unexplained residue of 531″. Thus, Einstein's theory, in its existing stage, can neither predict not account for the Mercurial anomaly.

(2) The author points out that Einstein's scheme is quasi-geometric, depending on the assumed existence of a four-dimensional ds^2 of the space-time of the whole universe, the geodesics of which are the paths of heavy bodies, and he has shown that such a scheme involves self-contradictions. Brillouin claims that the coefficients of the ds^2 may legitimately be assumed to depend on the coordinates of all the points of the system, and that all these coordinates vary as a coherent whole. This is perfectly legitimate, and gives a fourfold quadratic form, but, owing to the coherent variations of *all* the coordinates, the form is no longer a fourfold *linear* element; the motions are no longer defined by the geodesics of a universe, the considerations relating to the curvature of the universe become unmeaning, and the quasi-geometric formulation of gravitation vanishes. But Brillouin accepts the $g_{\mu\nu}$ as being the most general solutions of Einstein's equations. The author accepts amongst these solutions only those which are capable of definition by the true fourfold ds^2 originally assumed.

(3) Newton's and Einstein's systems differ so radically that the inference from their approximate agreement in the case of a single body, that they agree generally is as unjustifiable as it would be to argue that two curves

which nearly coincide within a limited area must necessarily be identical. Moreover, in the case of a single particle, each system is defined by a quadratic form with four variables. Einstein derives from them a system of co-variant partial differential equations. Of the mathematically possible systems he selects that of which Poisson's equation is the limiting form. This system being insufficient to define his coefficients, he selects from the possible integrals those which most nearly approach those of Newtonian mechanics. The divergence becomes obvious for more than one particle. Newton's method takes account of all the variables, the time playing the part of a canonical variable (*i.e.* simultaneous positions of the particles are considered, or plane sections of space-time for which t is constant are taken), and the development is effected by the ordinary theory of perturbations which is meaningless on Einstein's theory, in which gravitation is determined by curvature of the space-time. Here again, three of the coordinates of each point can be expressed in terms of the fourth, but there is no unique variable through which the movements can be correlated [see Abstracts 1484 (1922) and preceding abstract.] G. W. DE T.

821. *Gravitation and Quantum Theory.* II. **A. H. Bucherer.** (Ann. d. Physik, 68. 6. pp. 545–550, Sept. 14, 1922.)—In a previous communication [see Abstract 1954 (1922)] the author has derived gravitational effects on the basis of the quantum theory. The energy equation of the motion appeared there as an hypothesis which was adopted only as being probable. The present paper chiefly relates to the validity of this equation. Section I deals with a distinction between longitudinal and transverse masses in the gravitational field. Section II considers relationships with respect to the general theory of relativity. From the quantum theory in union with the result from Maxwell's theory a connection between energy and inertia which was verified by the experiments of Zeeman and Southern, the red displacement has been derived and later the formula for transverse mass. From the red displacement a relationship is given between time intervals which are measured without and within a gravitational field, and this leads, by means of the energy hypothesis, to the derivation of the formula for longitudinal mass, and thereby to the establishment of the equation for the kinetic energy and for the deflection of a light ray in the gravitational field. By a generalisation from the behaviour of light rays and extension of the consequences to ordinary matter, the equation of motion is applicable to the free motions of all kinds of masses and thereby the perihelion motion of Mercury is derived. From the standpoint of the present results it follows that, for the general theory of relativity, the necessity arises to distinguish between longitudinal and transverse masses by an introduction of mass. H. H. Ho.

822. *Equivalence in Relativity.* **E. Persico.** (Accad. Lincei, Atti, 31. ii. pp. 98–100, Sept., 1922.)—Mathematical deduction of the Principle of Equivalence in more precise and general terms. A. D.

823. *General Solution of the Static Problem of a Single Body on the Einstein Theory.* **A. Gullstrand.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 17. 3. pp. 1–5, 1922.)—The author here replies to a correspondent's difficulties and misunderstandings of his paper [Abstract 734

(1922)], and adds some further explanations suggested by them, and which may be of assistance to other readers of the paper in question.
G. W. DE T.

824. *The Lorentz Contraction and the Clock Paradox.* **K. Bollert.** (Zeits. f. Physik, 12. 3 and 4. pp. 189–206, 1922.)—The author continues the investigation, begun in a former paper [Abstract 2216 (1922)], of a rod moving in an inertial field in such manner as to remain either unstrained or without change of strain, and illustrates graphically some of the conclusions. He obtains a general solution of the case in which a body receives acceleration, not without consequent strains, but by the application of an impulse, such as might be communicated to a train by a push from a locomotive, so that after the dissipation of the resulting strain waves, the motion becomes steady. As a consequence of this general solution it is shown that a moving body, on becoming free from strain, immediately undergoes the exact Lorentz contraction, without the intervention of any forces of unknown origin, the necessity of which has been postulated by some relativists. The author next proceeds to deal with the so-called clock paradox. He takes the case of an observer A at rest in an inertial system, his world-line being OA, perpendicular to OX, the x-axis. Then OA is the time axis, and an observer B, moving along an arbitrary course in the space-time, is supposed to meet the observer A at O and A, and at each point they compare their clocks. The space-time interval OA is then common to the two tracks, so that it must be the same for each observer. The author verifies this by a rather lengthy analysis, using the formulæ obtained in the paper and embodying the assumptions that A measures his time so that the light velocity in any inertial system is constant, while B measures his so that the backward and forward velocities are everywhere equal to each other. He then explains that the rate of B's clock appears to A to be determined by: (1) The retardation due to the uniform motion of special relativity together with the parallel displacement of the time-plane; (2) the retardation of the rate wherever B's motion is accelerated and its acceleration where B's motion is retarded, both accompanied by corresponding rotations of the time-plane. G. W. DE T.

825. *Remarks on F. Selety's Paper, "Contributions to the Cosmologic System."* **A. Einstein.** (Ann. d. Physik, 69. 6. pp. 436–438, Dec. 19, 1922.)—It may be conceded that from the standpoint of Newton's theory there is much to be said for the hypothesis of the "molecular hierarchical" character of the structure of the stellar universe, although the hypothesis of the equivalence of the spiral nebulæ with the galaxy may be considered as refuted by recent observations. This hypothesis freely declares the non-curvature of the horizon and avoids Seeliger's conflict with Newton's law without conceiving matter as an island in empty space. Also from the standpoint of the general theory of relativity the hypothesis of the molecular hierarchical structure of the universe is *possible* but unsatisfactory. If the geometric and inertial properties of space be influenced or partly conditioned by matter, we are forced to conclude that this conditioning is complete, in accordance with the general theory of relativity, if the mean density of matter be finite and the universe spatially circumscribed. To illustrate this, though imperfectly, by a simple imaginary case, let it be assumed that our knowledge of gravitation would be acquired only by the accurate study of the mechanics of bodies available for laboratory experiments. Let the spherical form of the earth be unknown to us. We could then set up the following theory: There exists primarily a vertical "cosmic" field of gravity stretching in all directions into infinity. The earth extends downwards into infinity. Let its gravitating effect against the cosmic field of gravity be neglected. The cosmic field of gravity is modified by gravitating effects of masses on the earth's surface accessible to experiment. Although the assumed cosmic field of gravity and the fields of gravity of the masses accessible to experiment agree with Poisson's equation, yet would this conception be unsatisfactory for the reason that the cosmic field has been assumed without a material cause. The idea that the field of gravity, the main condition of the fall of bodies on the earth's surface, has no independent existence but is caused by the earth's body would certainly constitute a great advance. That nowadays the necessity of connecting the world's metrical and inertial field with physical causes is not equally insisted upon is due solely to the fact that this field is not so clearly felt as a physical reality, as in the above example, the physical reality of the "cosmic field of gravity." To a later generation this mental attitude will seem incomprehensible. Neither the "molecular hierarchical world" nor the "island world" fulfils Mach's postulate, according to which the inertial action of the single body is conditioned, as is its gravitational force, by the total of all the other bodies. It is difficult to understand how this flaw in his system escaped Selety's notice. The general theory of relativity shows, without considerations of a cosmologic nature, that the bodies of the first approximation behave as Mach's conception would lead us to expect. Finally, let a point be mentioned which, not only in Selety's treatise but in the literature of the subject, is a frequent source of confusion. The theory of relativity says: The laws of nature are to be formulated independently of any special choice of coordinates, the coordinate system having no counterpart in reality. The simplicity of a hypothetical law is to be judged only according to its general co-variant formulation. But it does not follow that the description may not be facilitated by a suitable selection of the frame of reference without clashing with the postulate of relativity. If, for instance, the actual world be approximately described by the "cylinder world" with uniformly distributed matter and the time axis be selected parallel to the generatrices of the cylinder, this does not imply the introduction of an "absolute time." There is no one system of coordinates to be preferred for the formulation of natural laws. It is not possible to define accurately such a system of coordinates as regards the actual world, even if that world be roughly approximated by means of the cylinder world. The principle of relativity does not assert that the world is to be described equally simply, or even in the same manner, in relation to all systems of coordinates, but only that the general laws of nature with regard to all systems are the same or, more exactly, that the hypothetically possible laws of nature in regard to their simplicity are to be weighed one against the other only in their generally co-variant formulation. [For Selety's paper see Abstract 40 (1923).] **E. F.**

826. *The Earth's Atmosphere as a Circular Vortex.* **[Miss] A. L. Beck.** (Monthly Weather Rev. 50. pp. 393–401, Aug., 1922.)—The investigations of V. Bjerknes into the theory of the general circulation of the atmosphere as a circumpolar vortex are discussed; the theory necessitates a surface of discontinuity between cold polar air on the one side and warm equatorial air on the other, which has been termed the "polar front." With cold air moving southwards and warm air moving northwards, the polar front may become contorted and a series of wave motions may be set up in the atmosphere, which will be propagated eastwards. Criteria are given for fixing the position of the polar front, and the relation between natural conditions and movements of the polar front is discussed. Investigations of J. Bjerknes and H. Solberg have shown that cyclones generally pass through definite stages of development, and tend to occur in families of from two to six.

The Norwegian method of forecasting by the Bjerknes theory is described for different weather types, and an attempt is made to apply the method to the weather maps of the U.S. Weather Bureau. Although the observations are not available in nearly such detail as in Norway, the surface of discontinuity can be traced, so that more exact forecasting should be possible when more detailed data are available. A. W. L.

827. *Life Cycles of Cyclones and Polar Front Theory of Atmospheric Circulation.* **J. Bjerknes** and **H. Solberg.** [Review by A. J. Henry.] (Monthly Weather Rev. 50. pp. 468–474, Sept., 1922.)—The history of cyclones is traced from birth, through definite stages of development, until death. In the initial stages of formation of a cyclone there are usually two adjacent currents, a warm one flowing from the west, and a cold one from the east. The boundary between these currents is initially straight, but where the new cyclone is to be formed it bulges towards the cold side, and the centre of the cyclone is found at the top of the projecting tongue of warm air. The bulge will increase, and the tongue of warm air will become narrower in the south, until the cold air, curving around the north of the warm air and arriving as a north-westerly wind, joins the cold air in front. This completely cuts off the supply of warm air, and the warm air in the centre will rise, the cyclone becoming "occluded." The boundary between the cold air from the front and rear of the cyclone will persist for a time and finally disappear. The cyclone has now become a nearly symmetrical vortex of cold air, which gradually dies out. Before dying out a fresh bulge may be set up in the boundary surface, thus giving birth to another cyclone. Hence cyclones may be said to occur in families, and it is stated that in a series of cyclones each cyclone usually follows a track south of the track of the preceding one.

A diagram consisting of four families of cyclones is given to illustrate the general circulation of the atmosphere round the pole and in the temperate zone. It is shown that a family of cyclones occurs on the boundary between the left flank of a polar current and the adjacent tropical current, while a moving anticyclone occurs on the right flank; thus anticyclones move at practically the same rate as families of cyclones. European observations in 1921 gave a period of about 5·5 days for a family of cyclones to pass a fixed meridian. It is suggested that this is closely related with Defant's period of 5·7 days for rainfall in the Northern Hemisphere. A. W. L.

828. *Pressure Distribution at Various Levels during the Passage of a Cyclone Across the Plateau Region of the United States.* **C. L. Meisinger.** (Monthly Weather Rev. 50. pp. 347–356, July, 1922.)—The effect of high land on the meteorological elements of a passing storm is investigated by considering a cyclone which crossed the Plateau region of the United States from February 10 to 16, 1919. A series of pressure maps is drawn at 12-hours intervals for heights of 1, 2, and 3 km. above sea-level. To reduce pressures for morning observations, considering long columns of air, the following lapse-rates of temperature per 100 m. are taken: 0·5° C. in the south, 0·3° C. in the middle, and 0·2° C. in the north of the Plateau. For short air columns a small positive or negative lapse-rate might apply; for evening observations and for stations along the Pacific coast the lapse-rates are higher. Slight errors in the mean temperature of the air column do not seriously affect the pressures. Pressures for the 1 and 2 km. levels are obtained from the hypsometric formula, but at 3 km. they are found by assuming that the current pressure differences, in the regions 1–2 and 2–3 km., are proportional to the average February pressure differences throughout these layers. The motion of upper and lower clouds are compared with the trend of the isobars at 3 and 2 km.; fair agreement is obtained, but deviations are more numerous at the lower level owing to topographic effects. The maps for sea-level and 1 km. do not coincide, showing that at the general level where the weather occurs the steep pressure gradients shown on the map for sea-level are not encountered. The centre of a depression moves northward as the altitude increases owing to the decrease of temperature from south to north. The change in weather after the storm passed from the Plateau to the plains is due to the stronger sea-level gradients, and to the increase in the intensity of the storm. A. W. L.

829. *Relation between Pressure-Difference and Wind-Velocity.* **R. Meyer.** (Meteorolog. Zeits. 39. pp. 389–392, Nov., 1922.)—The wind-velocity generated by a given distribution of pressure has been investigated from different points of view by Hann (Lehrb. d. Meteorologie, 3 Aufl., 1915, p. 426) and Exner (Dynamische Meteorologie, 1917, p. 93). To remove certain objections to both treatments the author goes into the question again, from the point of view of energy, expressing his result in the form (similar to Hann's): $v = \sqrt{2gh}$, where v is the velocity attained by a mass of air starting from rest at pressure p_1 and moving to another point at the same level where pressure is p_2, and h is the height above the starting-point where pressure would be p_2 on the assumption of a state of convective equilibrium. Friction is ignored in this treatment. M. A. G.

830. *Pressures and Specific Weights of the Air in a Normal Atmosphere.* **A. Rateau.** (Comptes Rendus, 175. pp. 1179–1181, Dec. 11, 1922.)—The author refers to the paper by R. Soreau [Abstract 435 (1923)]. From zero to 11 km. in the troposphere the curve of M as a function of z is sensibly rectilinear. It winds round the mean straight line, intersecting it four times. Soreau's equation for this line is $M = 19{\cdot}23 - 0{\cdot}22\,z$. The author deduced from the Lindenberg results $M = 19{\cdot}215 - 0{\cdot}221\,z$, which is almost identical. [The author here corrects an error: 19·215 was misprinted as 19·125 in Abstract 976B (1922).] Applying to the graph in the note of June 12th the values of L given by Soreau (after correcting the one relative to $z = 9$, which is 21·07 instead of 21·315), it is found that the representative points coincide exactly with the sinuous curve 44 deduced from the

Lindenberg results. Below $z = 5$ km. the points are slightly higher than the curve, which is not surprising, observations near the ground being very irregular. This striking agreement justifies the conclusion that the author's curve closely represents the relations of the air densities in a mean atmosphere. Above 5 km. the discrepancies do not exceed 2/1000 in relative value. This is, therefore, the curve to be henceforth utilised in calculating the reduction of the speed of aeroplanes to mean atmospheric densities at various heights, adding thereto the mean specific weight at sea-level, which in our climates approximates to 1·24. The remainder of the paper is devoted to a mathematical analysis of Soreau's results. E. F.

831. *Vertical Movements in the Atmosphere.* **G. Reboul.** (Comptes Rendus, 175. pp. 1165–1168, Dec. 4, 1922.)—The paper summarises some results on the ascending speed of balloons, obtained at meteorological stations during the war. Taking the mean rate of ascent during all types of weather as the normal, it was found that (1) the rate of ascent was considerably increased during cloudy weather, and increased with the amount of cloudiness; (2) combining this result with the law of Helmholtz, a depression moves with greater speed the more cloudy the sky. Since the prediction of the motion of a depression is of such great importance, the relation established, that the speed is greater in cloudy zones, should be of the greatest assistance. W. A. R.

832. *Atmospheric Turbidity over Frankfurt a.M. and over the Taunus Observatory.* **K. Boda** and **H. Roth.** (Meteorolog. Zeits. 39. pp. 369–374, Nov., 1922.)—A " turbidity factor " has been suggested in an earlier paper [see Abstract 422 (1923)]. The present paper discusses values of the factor deduced from solar radiation observations at the above places. It is in three parts, the first showing the diurnal and seasonal variation at the Taunus Observatory (alt. 820 m.). Broadly, the factor follows the surface air temperature in its diurnal range, while highest values occur in summer, then, in order, spring, autumn, winter. The second shows a connection with horizontal and upward " visibility " as measured at the observatory, while the third compares values at the two places, those at Frankfurt (alt. 100 m.), a large town, being markedly the greater. M. A. G.

833. *Free-Air Pressure Maps.* **C. L. Meisinger.** (Monthly Weather Rev. Suppt. No. 21. pp. 5–76, 1922.)—Deals with the preparation and significance of free-air pressure maps for the central and eastern United States. W. R. C.

834. *Unusual Haloes.* **W. J. Humphreys.** (Monthly Weather Rev. 50. pp. 535–536, Oct., 1922.)—X-ray analysis has shown that the oxygen atoms of an ice crystal are arranged in hexagonal patterns, so spaced that the ratio of the longitudinal to the lateral axes is 1·62. Hence the ratio of the height of a pyramidal ice crystal to the inner radius of its base must be some simple multiple or submultiple of 1·62. Taking the factor as 4/3, a pyramid is obtained whose sides are inclined at 24° 51′ to the longitudinal axis. It is shown that light passing through randomly directed ice crystals of this type, with or without hexagonal columns between the pyramidal ends, will give rise to the well-known

haloes of 22°, 46°, and 90°, and also to the unusual haloes of 8°, 17°, and 19°, which have been observed and measured with fair accuracy.
A. W. L.

835. *Meteorological Conditions for the Formation of Rain.* **J. Bjerknes and H. Solberg.** [Review by A. J. Henry.] (Monthly Weather Rev. 50. pp. 402–404, Aug., 1922.)—All Norwegian rains have been classified by the authors according to their mode of formation, examples of various types being given. The predominating influence in the formation of rain is the expansion of air; hence an investigation is made into the conditions which will cause air to expand. Orographic rain is caused by the ascent of air in passing over mountains, but the authors distinguish between pure orographic rain in Norway and the rain deposited by a westerly current which bears rain even over the sea. Summarising their conclusions concerning orographic rain, the authors state that: "Pure orographic rain, which necessarily forms as well in stable as in unstable currents, occurs only in connection with mountains at least 1000 m. high. Showers due to instability may, in particular cases, add considerable amounts to that of the pure orographical rain, and make even orographical rain possible in connection with smaller obstacles. The effects of orographical rain are strongly restricted by the tendency of all stable air currents to curve round the mountains horizontally." Cyclonic rain may be due either to warm air rising over a mass of cold air or to a moving mass of cold air undercutting a current of warm air. Conditions favourable to the development of local showers are discussed with reference to the topographic control exerted by the mountains of Norway, and it is concluded that the general distribution of pressure is not so important a factor in the occurrence of local showers as the stability and humidity of the air.
A. W. L.

836. *Formation of Hail.* **A. Artom.** (Accad. Lincei, Atti. 31. i, pp. 513–518, June 18, 1922.)—The electrical conditions for the formation of hail are discussed. This takes place in a medium rendered feebly conducting by ionisation in which occur insulating bodies, such as the nuclei of the hail. The ionisation is due (1) to the emissions from the sun, regarded as an incandescent body at a high temperature sending out corpuscles negatively electrified, and (2) to the action of the ultra-violet rays. Hail is usually seen in the hottest part of the day, when the ionisation by ultra-violet rays is strongest. Hail is formed frequently between rain clouds with high electric charges, and water-vapour in the presence of ice has the property of feeble electric conductivity. In these circumstances the electric field causes an action of rotation which acts on the small drops of water. A piece of ice suspended in benzol begins to rotate and continues this motion as long as the suspending thread permits. Such a rotating mass forms a solid of revolution, and such are seen in the case of hail. Helicoidal forms due to the additional action of gravitation are also observed.
J. J. S.

837. *The Lower Oblique Arcs of the Anthelion.* **E. W. Woolard.** (Monthly Weather Rev. 50. pp. 537–539, Oct., 1922.)—The lower oblique arcs have been explained by Hastings as due to light which, at a high altitude of the sun, falls upon the upper sloping face towards the sun of a hexagonal ice crystal having two side faces horizontal, and after being internally reflected by a base emerges from the lower horizontal face. A geometrical computation is given of the luminous arcs produced by the rotation about a vertical axis of any dihedral refracting angle, with a horizontal edge. The complete theoretical halo is given and shows the haloes of 22° and 46°, the parhelic circle, and the upper and lower oblique arcs passing through the anthelion. A. W. L.

838. *Weather Forecasting.* **V. Bjerknes.** (Phys. Zeits. 23. pp. 481–488; Disc., 488–490, Nov. 15 and Dec. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—An outline of the progress made by the author and his assistants, during the last 16 years, in the development of weather forecasting as a branch of applied physics. Just as the problem of astronomy, as applied mechanics, is to find the new position of the displaced heavenly body, that of meteorology is to find the new position of the displaced masses of air and the condition in which they reach this position. The present stage reached is represented by the methods employed in forecasting in Norway, in which the identification in the atmosphere of surfaces of discontinuity of the various elements separating masses of air of different quality, plays an important part, and of which a useful summary is given. M. A. G.

839. *Graphical Logarithmic Extrapolator.* **C. G. Abbot, F. E. Fowle,** and **L. B. Aldrich.** (Smithsonian Inst. Astrophys. Obs., Annals, 4. pp. 84–86, 1922.)—An instrument useful for computing the solar constant and the atmospheric transmission coefficient directly from the intensities of radiation measured by the bolometer and the air masses traversed in each case. A linearly divided bar forms the x axis upon which air masses are read. Corresponding ordinates are read directly upon a series of 16-inch slide rules clamped at right angles to this bar. The y axis is a 32-inch slide rule with a 16-inch slider carrying at its upper end a bar at right angles which has a length on the x axis equal to − 10 units. At the end of this is attached a wire whose other end is kept wound on a spring drum which can be clamped in any position on a bar parallel to the y axis and at the other side of the instrument. In using the instrument, the sliders are set to certain correction factors and the cursors on these to the observed measurements of intensity. The slide rules are set with their abscissæ, the air masses, corresponding to each observation. The y axis slider and the spring drum are so adjusted that the stretched wire lies closely along the line of the cursors. Its intersection with the y axis then gives the solar constant and the distance of this ordinate to the top of the y axis slider gives the logarithm of the atmospheric transmission coefficient. A. Wh.

840. *Solar Radiation Outside the Atmosphere.* **C. G. Abbot, F. E. Fowle,** and **L. B. Aldrich.** (Smithsonian Inst. Astrophys. Obs., Annals, 4. pp. 323–366, 1922, and Smithsonian Misc. Coll. 65, No. 4.)—A reply to various criticisms of previous work on the solar constant. New results are also given with recording pyrheliometers attached to sounding balloons. These comprise a blackened disc for receiving the radiation, a thermometer for registering the temperature of the disc, and a drum carrying photographic paper and driven by a clock, upon which the shadow of the mercury column is recorded. A barometer records simultaneously upon the drum, the important quantity being the pressure corresponding to any reading of the pyrheliometer rather than the actual altitude. A description of the balloon gear and the calibration of the apparatus is given. The final conclusion reached is that the value of the solar constant outside the atmosphere is 1·86 calories per cm.^{2} per minute, which agrees well with the value 1·93 deduced from observations at ground-level. A. Wh.

841. *Measurements of Solar Radiation*, 1912–20. **C. G. Abbot, F. E. Fowle,** and **L. B. Aldrich.** (Smithsonian Inst. Astrophys. Obs., Annals, 4. pp. 99–128, 1922.)—Tabulated results of pyrheliometer measurements of solar radiation made at Mount Wilson, California, 1912–20, at Hump Mountain, North Carolina, in 1917–18 and at Calama, Chile, in 1918–20. The outstanding feature is the general reduction of radiation due to the dust from the eruption of Katmai, Alaska, June 6, 1912. The effect was strong throughout July and August, 1912, and was felt throughout 1913. A. Wh.

842. *Measurement of Sky Radiation.* **C. G. Abbot** and **L. B. Aldrich.** (Smithsonian Inst. Astrophys. Obs., Annals, 4. pp. 65–84, 1922.)—A comprehensive description of a new instrument primarily designed for measuring sky radiation and called by the authors the Pyranometer. Two modifications are described. In the one, the radiation falls on two blackened strips of manganin attached to massive copper terminal blocks. The thickness of the strips is unequal and hence cooling by conduction is unequal also. The unequal heating is exactly duplicated by passing a current through the strips in parallel, the resistance in the circuit being so adjusted that the total heat evolved in each is the same. The temperature differences are compared by small platinum-tellurium thermojunctions in contact with each strip and a sensitive galvanometer. The second form has one strip only and is more sensitive, but less reliable. Many precautions are described and comparison favourably made with the pyrheliometer. The uses of the instrument for measuring the radiation from the whole or small regions of the sky and the solar constant are described. A. Wh.

843. *The Age of the Earth.* (*a*) *Considered Astronomically.* **E. W. Brown.** (Am. Phil. Soc., Proc. 61. 4. pp. 283–285, 1922.) (*b*) *From the Point of View of Radio-Activity.* **W. Duane.** (Am. Phil. Soc., Proc. 61. 4. pp. 286–288, 1922.) (*c*) *The Geological Aspect.* **T. C. Chamberlin.** (Am. Phil. Soc., Proc. 61. 4. pp. 247–271, 1922.) (*d*) *The Palæontology Aspect.* **J. M. Clarke.** (Am. Phil. Soc., Proc. 61. 4. pp. 272–282, 1922.) W. A. R.

844. *Arabic Theory of Tides.* **E. Wiedemann.** (Ann. d. Physik, 67. 5–8. pp. 374–387, June 29, 1922.)—The paper gives a translation of a script by Al Kindî, in which a tidal theory, supported by experiment, is outlined, depending partly on flow from earth caverns and partly on the "alteration" of air into water. W. A. R.

845. *The Non-Simultaneity of Magnetic Storms.* **L. Rodés.** (Terrest. Magn. 27. pp. 161–166, Dec., 1922.)—Bauer has concluded that magnetic storms, which commence abruptly, progress more often towards the east than towards the west, with a velocity such that it would require, on the average, about four minutes to encircle the earth at the equator [Abstract 1338 (1910)]. The author has observed, in the case of five well-defined storms, subsequent to the above, that they began suddenly over a very large range of longitude, 186 degrees in the case of one of them and 171 degrees in the case of two of them. There are, however, a number of recent cases in which a propagation is strongly suspected; and the author has investigated the theory that this is due to the passage of the earth, in its orbital motion, into a stream of electrical particles sent out from the sun; the storm should be first observed by places on the "front meridian," which first enters the stream; and allowing for a possible "transverse velocity" of the electrical particles of 2 kilometers per second, due to the rotation of the sun, the time required for the earth to become involved in the stream is calculated to be about 6½ minutes, which is fairly close to Bauer's number. It is suggested that induction effects may account for the difference. It is found that, when a number of recent observations are examined from this point of view, there is some evidence that storms commence earliest at stations near the front meridian; there are very conspicuous exceptions to the rule; but the agreement is close enough to justify further investigation. It is also possible that some of the electric streams are of cosmic character, and are not projected from the sun. H. N. A.

846. *Astronomical Photographic Photometry and the Purkinje-Effect.* **F. E. Ross.** (Eastman Kodak Co. Research Lab. Comm. No. 150. Astrophys. J. 56, pp. 345–372, Dec., 1922.)—The four methods of astronomical photographic photometry are outlined; two depend on the sideway scattering of light in the emulsion, or on the depth penetration; two make use of the *total* action, and have therefore a higher sensitivity. "Astrogamma" and "Gamma" are defined. Astronomers are generally interested in formulæ connecting photographic density and exposure only in so far as the photographic exposure E involves the stellar magnitude M and exposure time t. This relationship has been given three forms: (1) The reciprocity law; (2) Schwarzschild's law; (3) Kron's law, which, though fundamentally at variance, are all of undoubted applicability in numerous cases. The author reviews the formulæ for the relation between photographic diameters, stellar magnitude, and exposure as given by Bond, Scheiner, Charlier, and others, down to the Greenwich formula, ($\sqrt{d} = a + b \log \mathrm{I}$), and shows that this last does not hold good for very small images, so proposes a new formula, ($\sqrt{(d + h)} = a + b \log \mathrm{I}$) where a, b, and h are constants. To obtain data as to how *turpidity*, (Δ), that is rate of growth, depends on the size of the optical image, the author photographed in the precision reducing camera a test object having nine circular holes of diameters from 0·16 mm. to 2·3 mm., the exposure times ranging from 1 second to 32 minutes, and found that Δ is not constant, but increases with the intensity, say, from 9 to 12 μ when the intensity is multiplied three hundred fold. The conclusion is that deduced relative magnitudes are dependent on the exposure time, Δ being a function of the star's magnitude. This phenomenon is similar to the Purkinje or colour-gradation change, and in astronomical photometry should not be overlooked. The variation of Δ with wave-length, the *photographic Purkinje-effect* is very important, and a brief historical summary of it is given. Abney found that the least steep gradation is that given by the monochromatic light to which the simple silver salt experimented with is most sensitive, and that it grows steeper as the wave-length of light employed deviates from this on either side. The author suggests in explanation that for emulsions whose grains are of equal sensitivity, " Gamma " is a maximum, and as the number of grain-groups of varying sensitivity increases, " Gamma " decreases. He points out that the tendency of a photographic plate to " reversal " must have a bearing upon the gradation of a plate. A. S. D. M.

847. *Daily Variation in Clock Corrections.* **H. R. Morgan.** (Astron. J. 34. pp. 163–164, Nov. 29, 1922.)—The daily clock-correction variations from 1913·5 to 1920·9, as determined from observations taken on the 9-inch transit circle of the U.S. Naval Observatory, are practically negligible just as they were in the years 1903–1911 [see Abstract 1098 (1922)]. The mean value $(+ 0''\cdot 003)$ of the variation in clock corrections during the night is similar in size, but of opposite sign, to that $(- 0''\cdot 007)$ derived from the work of the eight preceding years. The clocks have the same rate day and night. A. S. D. M.

848. *Interferential Measures of Faint Diameters.* **M. Hamy.** (Comptes Rendus, 175. pp. 1123–1129, Dec. 4, 1922.)—An extension of Michelson law to the case in which the width of the slits as compared with their distances cannot be neglected. If ϵ = diameter of the source, a = width of slits, l = separation of their centres, θ = angular distance from the middle of the star image, parallel to the line of centres of the slits, then if I is the luminous intensity in the direction, θ, the author obtains the equation :

$$\mathrm{I} = 2\int_{-1}^{+1} \sqrt{1 - u^2}\left[\frac{\sin m\alpha(u - \tau)}{m\alpha(u - \tau)}\right]^2 \cos^2 m(u - \tau)d\tau,$$

where

$$\theta = \frac{\epsilon}{2}\tau;\ \ a/l = \alpha;\ \ m = \frac{\pi l\epsilon}{2\lambda};\ \ \mathrm{S}(m) = \frac{4}{\pi}\int_0^1 \sqrt{1 - u^2}\cos 2mudu;$$

$$\mathrm{T}(m) = \frac{4}{3\pi}\int_0^1 (1 - u^2)^{\frac{3}{2}}\cos 2mudu,$$

from which he derives $d\mathrm{S}/dm = 4m\mathrm{T}(m)$. He tabulates for values of m the numerical functions S(m) and T(m), and finds that S(m) is zero for $m = 1\cdot 916$. If $\alpha = 0$, we find $\epsilon = 1\cdot 22\,\frac{\lambda}{l}$, which is Michelson's formula. If α is not zero, but a small fraction of unity, he obtains $\epsilon = \frac{\lambda}{l}(1\cdot 22 + 0\cdot 15\,\alpha^2)$. A. S. D. M.

849. *Cosmic Chemical Processes.* **S. Arrhenius.** (Zeits. Elektrochem. 28. pp. 405–411, Oct. 1, 1922. Paper read before Deut. Bunsen. Gesell., Leipzig, Sept., 1922.)—Covers the following : The source of the radiant energy of the hot stars. Discussion of the ideas of J. R. Mayer, v. Helmholtz, the radium theory (insufficient), combination of electrons with nuclei (insufficient), building up of positive nuclei (sufficient). The probable history, from a cold mist to hot aggregates. The part played by nebulium in building up atoms ; isotopes. Maximum temperatures attained, thereafter to fall. Eddington's views discussed. Classification of stars; the giant stars surrounded by dust-clouds very gradually sinking. Discussion of data. A. D.

850. *Can the Mean Density of the Universe be Finite?* **W. D. MacMillan** and **E. Borel.** (Comptes Rendus, 175. pp. 1044–1046, Nov. 27, 1922.)—In an article published in Scientia in February, 1922, the author defined a class of numbers

$$\text{(Class A)} \sum_{i=-j}^{i=+k} A_i 10^i (j,\ k = 0,\ 1,\ .\ .\ .\ ,\ \infty)$$

where A_i is -1, 0 or $+1$, and constructed a universe of points such that the coordinates of each point are numbers of Class A. In the Comptes Rendus of April 10, 1922, E. Borel defined a class of numbers

$$\text{(Class } \alpha\text{)} \pm \sum_{i=0}^{k} a_i 10_i\ (k = 0,\ 1,\ .\ .\ .\ ,\ \infty),$$

where a_i is 0 or $+1$, and constructed a universe of points such that the coordinates of each point are numbers of Class α. It follows from these definitions that Class α is a subclass of Class A and that the universe defined by Borel is a part of that defined by the author. The numbers of Class A are formed of figures 0, 1, 8, and 9, and contain all orders of integrals and decimals, while those of Class α are the positive and negative integrals which can be written with the figures 0 and 1. The main point in the construction of the author's universe is to display the principle of relativity of dimension and to avoid as far as possible a universe having " essentially particular " regions. Far preferable is the hypothesis of a universe " uniform in the aggregate," despite Seeliger's objection that an infinite and uniform universe is incompatible with the absolute accuracy of Newton's law of gravitation. Seeliger's objection rests on three postulates: (1) The universe is infinite and uniform. (2) Newton's law of gravitation is strictly accurate. (3) In a symmetrical situation it is legitimate to proceed to the limit non-symmetrically. The third postulate is not explicitly formulated, but is in effect utilised. If we replace it by 3′, *viz.* in a symmetrical situation it is not legitimate to proceed to the limit otherwise than symmetrically, Seeliger's objection to the simultaneous validity of postulates 1 and 2 falls to the ground. **E. Borel** remarks, in commenting on the previous communication, that his object was to escape logically from the conclusion that the universe is finite, a conclusion resulting from the hypothesis of a density " uniform in the aggregate " when Newton's law is corrected by the complementary terms necessitated by the law of relativity. If one adheres to the point of view of the classical mechanics of the nineteenth century, Seeliger's objection does not seem to be invalidated by the considerations of symmetry invoked by MacMillan. It seems difficult to admit that compensation between infinite contrary actions can be effected by symmetry. E. F.

851. *System of an Infinite Universe.* **C. V. L. Charlier.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 16. 22. pp. 1–34, 1922. In

English.)—N_1 stars form a galaxy of the first order of which the Milky Way is an example. The spiral nebulæ are similar galaxies and N_2 of these form a galaxy of the second order. An infinite series of galaxies of higher orders is postulated and their distributions are so adjusted that objections to an infinite universe made by Olbers (on the grounds of finite luminosity at every point) and by Seeliger (on the grounds of finite gravitative force at every point) are satisfactorily met. These two conditions are shown to lead to the same inequality. The mean and limiting distances, velocities, magnitudes, and total numbers of galaxies are investigated and the results correlated with observation. The distribution of all the nebulæ in the Dreyer catalogue is tabulated and hence a section of the second order galaxy is obtained. The natural periods of systems of similar type are calculated on the assumption that a great number of encounters between the components do not sensibly cause their motion to deviate from the mean. The numerical results and their comparison with observation are too numerous for detailed abstraction. A. Wh.

852. *Radiative Equilibrium: The Law of Darkening of the Disc towards the Limb in a Star.* **E. A. Milne.** (Roy. Soc. Phil. Trans. 223. pp. 201–255, Nov. 27, 1922.)—The law of darkening of stellar discs is used for finding the orbits and densities of eclipsing binaries and the angular diameters of stars by the interferometer. This law has been found for the sun both for integrated radiation and for separate wave-lengths. In this paper the law of darkening of a star is compared with the distribution of its spectral energy, with departure from grey body properties, and with molecular scattering. The author first considers the law for grey absorbing matter in radiative equilibrium, without scattering. The mass of material is stratified in parallel planes, possessing a plane outer boundary [see Abstract No. 853 (1923)], T being the temperature at any point τ, and T_0 at the boundary, and he finds that the law of darkening in wave-length λ depends only on the product λT_0 and not on λ and T_0 separately. Thus, if we know the law for all wave-lengths for a particular T_0, we know it for a star of any other effective temperature. As λT_0 increases, the ratio of intensity at the limb to that at the centre steadily increases up to the value 0·8 (approx.). For integrated radiation the darkening is independent of temperature, so that, as this increases, the decreased darkening in the longer wave-lengths is exactly compensated by the increased energy thrown into the shorter wave-lengths. On strict radiative equilibrium, with no selective absorbing and no scattering, blue stars should show decreased contrast in any given wave-length, as compared with red, but should show the same darkening in integrated radiation. Next, for the law of darkening for a purely scattering atmosphere with no emission or absorption, the material is taken as bounded internally by a plane radiating and absorbing surface, externally by a plane boundary with no radiation incident from outside. Towards the external boundary, distribution of radiation in direction will depend less on the source and more on the laws of scattering, so that the law of darkening for a thick scattering atmosphere depends only on the law of scattering and not on the law of darkening of the background. Scattering increases as the 4th power of the frequency, but variation in intensity of scattered light is independent of wave-length; it is proportional to $1 + \cos^2 \beta$, where β is the angle with the direction of the unscattered beam. Ultimately the law of darkening of the radiation issuing from the atmosphere becomes the same for all wave-lengths. The *intensity* of the emergent radiation is smaller in blue light than red, but the ratios of intensities in any two given directions must be the same everywhere on the disc. Intense scattering gives the same law for all colours; selective or general absorption gives darkening increasing from red to violet, affording a method of distinguishing between absorption and scattering in stellar atmospheres. On the sun, its energy curve cannot be attributed either to selective absorption or emission in the radiating layers, or to scattering, and the paradox that the darkening of the sun's limb is nearly that of a black body, whilst the spectrum shows that it is not a black body, is still unexplained. It is natural to suggest that we have a non-black photospheric emission and a scattering atmosphere, but this is inadequate. The author suggests processes in the thin layers producing the Fraunhofer spectrum.

A. S. D. M.

853. *Radiative Equilibrium; Insolation of an Atmosphere.* **E. A. Milne.** (Phil. Mag. 44. pp. 872–896, Nov., 1922.)—The author criticises Gold's theory put forward in 1908, and shows that if the atmosphere is divided into two shells, the troposphere (lower) and the stratosphere (upper), the stratosphere cannot be in strict radiative equilibrium unless its optical thickness for low-temperature radiation is zero, even if it is in radiative equilibrium as a whole. He supposes that the material is stratified in parallel planes and subject at its outer boundary to a parallel beam (such as the solar radiation), and that it is infinitely thick and in radiative equilibrium throughout. He finds a definite limiting temperature in the far interior as well as at the outer boundary. If T_0 is the boundary temperature, T_1 the effective temperature of the whole mass viewed from outside, and T_∞ that in the far interior, he finds, $T_\infty^4 : T_1^4 : T_0^4 = 3/2 : 1 : 3/4$. The material has been taken as "grey" (*i.e.* has an absorption coefficient the same for all the wave-lengths that are important, in this case those in low-temperature radiation), but if the material has a different coefficient of absorption for the incident radiation (say equal to n times that for its own low-temperature radiation), then $T_\infty^4 = 2T_0^4/n$. Next, if the external radiation is not normal to the surface but incident at an angle α, then $T_\infty^4 = 2 \cos \alpha T_0^4/n$, and for a sufficiently oblique incidence, the boundary is warmer than the interior. When the solar radiation is nearly tangential, its effective intensity is weak, but owing to its obliquity it is entirely absorbed in a thin layer close to the surface if n is not zero. When $\cos \alpha = \frac{1}{2}n$, the state is isothermal everywhere; and when $> \frac{1}{2}n$, the temperature steadily decreases inwards in the interior. If the effect of rotation is taken into account, for a given latitude λ an approximately isothermal state ($T_\infty = T_0$) is obtained for $\cos \lambda = n/\sqrt{2}$. The author discusses the effect of an internal boundary; of the "green-house" effect; of a partially convective atmosphere; and the boundary between troposphere and stratosphere. From an application of the results to the earth's atmosphere, it is inferred that the variation of the temperature cannot be accounted for, on radiation principles, unless the total radiation of the earth to space is greater in high latitudes than in low latitudes. This is probably the case and the observed distribution of stratospheric temperature is probably connected with the general circulation of the air, but the increased direct absorption of solar energy in the upper levels in high latitudes must have some effect. Incidentally he points out that the *actual* temperature of the stratosphere over S.E. England must be very close to the *mean* temperature over the earth, and this perhaps is partly due to the fact that the latitude of England is close to 60°, and such an angle of incidence for the solar rays plays a special part in the theory. A. S. D. M.

854. *A Double Regularity of the Solar System.* **M. Pierucci.** (N. Cimento, **24**. pp. 221–234, Oct.–Nov.–Dec., 1922.)—Empirical expressions giving the distribution of planets, satellites, and comets are discussed. Ruling out those containing more than one arbitrary parameter, two types of expression are found to be applicable, one exponential in form, the other giving a linear relation between mean radius and a series of integers. Examples of these are given by Armellini: $a_n = 1\cdot53^n$ where a_n is the mean radius and n an integer, and by the author in earlier papers: $a_n = n$ which can also be expressed in the form: $A_n = n^2$ where A_n is the area of the orbit. Armellini's expression can be transformed to: $T_n = 2^n$ where T_n is the periodic time, by a suitable choice of units. In these forms the expressions are applied to the solar system. Two criteria present themselves in the choice of the best form of empirical expression; firstly, the magnitude of the mean error and, secondly, the proportion of lacunæ for which bodies are predicted but do not exist. It appears that all components of the solar system obey approximately one or other of these laws, and the author tabulates the agreements, lacunæ and mean errors for each component of the solar system and indicates which type of expression is followed in each case. In the whole of his scheme there are forty agreements and twelve lacunæ, while the mean error is 3·02 %. It is suggested that some dynamical explanation of these relations can be found. A. Wh.

855. *The Sun and Sun-Spot Periods.* **L. Zehnder.** (Phys. Zeits. **23**. pp. 550–552, Dec. 15, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—According to prevalent opinion the origin of the surface phenomena protuberances, faculæ, and spots lies in the sun's interior. Is it possible to account for the periodicity of these phenomena, especially of the sun-spots, by interior processes? The author's view is that a solution of the problem is to be found in the zodiacal light. The meteorites move towards the sun in parabolic orbits. As they draw near to the sun they form swarms. Many of them plunge into the sun in the direction of the termination of their orbit, that is to say slantingly, with a velocity of, in round figures, 600 kilometres a second. In consequence of this enormous velocity they plough deep channels in the gaseous solar globe, become heated to a very high temperature, explode, and expel solar gases, together with those generated by themselves, through the channels beyond the sun's surface. Compact meteorite swarms generate eruptive, less dense swarms nebulous, protuberances. Those meteorites which do not plunge immediately into the sun are continually conveying fresh masses to the zodiacal light, to whose ordered motion, owing to innumerable collisions with other meteorites, they gradually conform. The smaller the bodies the more susceptible their motion to a resisting medium. Cosmic dust has its velocity diminished by the ether, whose existence can no longer be denied. Thus the meteorites of the zodiacal light move in diminishing spirals towards the centre of gravity of the solar-planetary system. At each conjunction with planets the sun strips off a number of meteorites which explode and burn, thus producing the characteristic phenomena of the solar surface and accelerating the rotation of the solar equator. But the planetary revolutions, through the resistance of the ether, are also effective in producing sun-spot periods, because the translation motion of the solar system through the ether is accompanied by a corresponding displacement of the entire zodiacal light towards the solar-planetary centre of gravity. Thus at each half of its periodic revolutions the sun again strips off meteorites from the displaced zodiacal light. The solar orbit periods are thus reflected in the sun-spot periods. The author considers that the sun-spot periods constitute one of the strongest proofs of the existence of the ether. E. F.

856. *The Quantitative Determination of the Red Displacement.* **J. Weber.** (Phys. Zeits. 23. pp. 548–550, Dec. 15, 1922.)—The frequency change of light oscillations on the general theory of relativity for a fall of gravitational potential has been already investigated for the earth-sun system. No satisfactory experimental data, however, have yet been recorded, although Freundlich and Kohl [see Abstract 481 (1922)] have obtained a qualitative result in a more or less observable red displacement by considering the fixed-star system. The present author considers that for a rigid calculation the necessary data can be obtained from double stars whose distance from the sun is ascertained by trigonometrical measurement, thereby enabling the fall in gravitational potential between earth and star to be calculated. For this purpose Sirius has been selected, and the astronomical data of Hertzsprung, Bottlinger, Ludendorff, Kobold, Bernewitz, Guthnik, Doberck, Lohse, and Zwiers utilised for the calculation. After taking account of the Doppler-effect for line H_γ, a displacement of 0·016 Å.U is found with respect to the corresponding earth line at the red end of the spectrum. H. H. Ho.

857. *Occultations and the Determination of the Moon's Place.* **R. T. A. Innes.** (Union Obs. of S. Africa, Circ. 55. pp. 149–159, May 16, 1922.)—A discussion of the possibility of very short-period fluctuations in the moon's motion. The author sets forth, first the corrections for the position of the Union Observatory, then the values adopted for the moon's parallax, the moon's semi-diameter, and the personal equation of observation of an occultation (at the dark limb, or 1st or 2nd magnitude stars at the bright limb) at disappearance and reappearance. An isolated occultation is of small value because of the irregularities of the moon's limb, and the author adduces as an example the occultation of Alcyone on October 6, 1876, which though visible in both phases all over Europe was only usefully observed in Germany. He gives the formulæ for reduction used at the Cape, and takes as an example the occultations observed after new moon, October, 1901, finding what seems to be a real and steady change in $\Delta\alpha$ between October 18th and 27th. He points out that from 1908, the Greenwich results show the errors of the moon's place as determined by transits both of the limbs and of Mösting A, with both transit circle and altazimuth, and suggests that if craterlets similar to Mösting A could be found near both following and preceding limbs, this form of observation could be much extended, Lastly he points out that the photographic determinations of the position of the moon (explained in Harvard Annals LXXII, 1; LXXVI, 7; LXXX, 11; and LXXXI, 5) confirm violent fluctuations in the moon's longitude when disclosed by the Greenwich eye-observations. The author pleads for an allied campaign of (1) meridian observations (including Mösting A), (2) photographs, (3) occulations, which might result in a very precise knowledge of the moon's place in every part of the lunation and perhaps supply a definitive answer as to whether the run of the errors in $\Delta\alpha$ are real, and whether there are short-period inequalities in the moon's motion. A. S. D. M.

858. *The Source of Luminosity in Galactic Nebulæ.* **E. Hubble.** (Mt. Wilson Obs. Contrib. No. 250. Astrophys. J. 56. pp. 400–438, Dec., 1922.)—This paper is a quantitative test of the theory that stellar radiations are the source of luminosity of galactic nebulæ. Particular stars can be selected that are involved in or associated with practically every known diffuse nebulosity, and if their spectra are earlier than B_1, the nebular spectrum is emission, if later it is continuous, if of B_1, the spectral characteristics are mixed. The method employed is to determine the surface exposure times just necessary to register the nebulosity under standard conditions; if the magnitude m is plotted against log a (where a is the maximum angular extent of nebulosity), it becomes evident that for the 82 nebulæ used, the extent of nebular illumination is a function of the stellar luminosity and the relation is approximately linear; it is fitted by $m + 5 \log a = 11 \cdot 9$. The nebular luminosity obeys the inverse square law with the associated stars as sources of illumination. Thirteen points lie above a theoretical limiting curve, but these stars show a colour excess which renders it probable in these cases that there is absorbing material, scattering the light between the earth and the star, which is thereby rendered fainter than it would otherwise be. The general conclusion is that within the errors of observation, the hypothesis holds good that diffuse nebulæ derive their luminosity from involved or neighbouring stars, and that they re-emit at each point, exactly the amount of light radiation which they receive from the stars. Where stars of sufficient brightness are lacking in the neighbourhood, or if present are not properly situated to illuminate the nebula as seen from the earth, the clouds of material present themselves as dark nebulosity. Eighteen of the 82 nebulæ show emission spectra, though otherwise they evince no systematic characteristics; the stars associated are nearly all Oe5 and Bo types, and hence the nebular luminosity is not simple reflection, but the continuous radiations from the stars are absorbed by the nebulosity and completely re-emitted as discontinuous radiations within the same range of wave-lengths. The emission nebulæ with no continuous spectrum merge smoothly into the continuous with no emission, as their dominating stars pass from Oe5 to Bo. Applications of this new principle give for the spiral M 33 a probable distance of 30,000 parsecs; for the sun (whose photographic absolute magnitude is about $+ 5 \cdot 65$) a power of illuminating a surface to a brightness of $24 \cdot 32$ magnitudes per square second of arc, at 470 times the distance of Neptune; and for Rigel (with $- 5 \cdot 58$ photographic absolute magnitude) luminosity to a distance of nearly $12^\circ \cdot 5$, corresponding to nearly 100 light years.

The planetary nebulæ do not give as clear or consistent results, and their discrepancies may be due to a difference between the spectra of the nebulosity and of the nuclei which have their maximum energy in the ultra-violet; or it may indicate that the radiations which excite the luminosity are chiefly corpuscular. A. S. D. M.

859. *Proper Motions from the Blink-Microscope.* **R. T. A. Innes.** (Union Obs. of S. Africa, Circ. 55. pp. 133–137, May 16, 1922.)—A pair of plates of the Larger Magellanic Cloud and of the Lesser Magellanic Cloud (each pair sixteen years apart) have been measured and examined by the author and H. E. Wood. Twenty-five variables have been identified on the smaller cloud, and 5 on the larger, by means of the plates given in Vol. LX, of the Harvard Annals, but these are somewhat uncertain; in both clouds the range of variation is much larger than that found at Harvard Observatory. For the smaller cloud proper motions, the directions of the drifts are: Solar motion, 85°·3; Drift I, 79°·1; Drift II, 235°·4; and were given for the larger in the U.O. Circular, No. 43. p. 377. From the nature of the blink-examinations, only relative changes can be detected, and the work here given shows no indications of the movements of the clouds themselves, only of the stars which are probably between us and the clouds. A. S. D. M.

860. *Direct Calculation of the Secular Perihelic Displacement of Planets on the Hypothesis that Gravitation is of Electric Origin. Application to the Planet Mercury.* **L. Décombe.** (Comptes Rendus, 175. pp. 1194–1196, Dec. 11, 1922.)—In further developing the thesis discussed in a previous paper [Abstract 568 (1923)], the author endeavours to estimate the action of the sun on a given planet, taking into account the electric induction phenomena, on the supposition that the distance between the two bodies is slightly less than that at which the influence of electric induction begins to be appreciable. Let M be the sun's mass, m that of the planet, $M\sqrt{\phi}$ and $m\sqrt{\phi}$ the equivalent fictive charges, r the distance between the two bodies. The fictive charge $M\sqrt{\phi}$ of the sun generates an electrostatic field H, the value of which at distance r is $M\sqrt{\phi}/r^2$. This field acts by induction on the planet, imparting to it an electric moment

$$\mathfrak{M} = \frac{K-1}{K+2}a^3 H$$

a being the radius of the planet and K its mean inductive capacity. The force which effectively determines the planetary motion may be expressed by

$$f = \phi\frac{Mm}{r^2}\left(1 + 2\frac{M}{m}\frac{a^3}{r^3}\frac{K-1}{K+2}\right)$$

The complementary term in brackets is always very small and therefore modifies only very slightly the Keplerian laws of motion. It obviously implies a secular advance of the perihelion expressed by the formula

$$\epsilon = 3\frac{M}{m}\frac{a^3}{A^3}\frac{N}{1-\frac{13}{4}e^2}\left(\frac{K-1}{K+2}\right) \quad \ldots\ldots\ldots\ldots \quad (1)$$

A being the semi-major axis of the orbit, e its eccentricity, and N the number of revolutions in a century. The quantities $\mathfrak{M}$, m, a, A, N, and e are well known for each planet. Supposing that the secular advance of the perihelion be due to the phenomena here considered, the preceding formula enables us to calculate this quantity as a function of the mean inductive capacity K of the planet. Reciprocally we can by means of formula (1) estimate the mean inductive capacity of a planet, the secular displacement ϵ of its perihelion being known. *Application to the planet Mercury*: For this planet that part of the perihelic advance not due to planetary perturbations is a minimum of 38″ in a century. We therefore write $\epsilon = 38'' = 0\cdot000184$ radian. Further, for Mercury,

$$\frac{\mathfrak{M}}{\mathrm{M}} = 595\cdot10^4\,; \quad \frac{a}{\mathrm{A}} = \frac{1}{24500}\,; \quad e^2 = 0\cdot042\,; \quad \mathrm{N} = 415.$$

From formula (1) we thus easily deduce $\mathrm{K} = 2\cdot4$, which agrees perfectly with the value obtained, in a first approximation, for the mean inductive capacity of the earth calculated on the same principles, starting from its experimental magnetic moment. Reciprocally, admitting for the inductive capacity of Mercury a mean value of 2·4, formula (1) gives for the secular displacement of its perihelion the 38″ not due to the action of the other planets. E. F.

861. *Photographic Magnitudes and Photographically Effective Wave-Lengths of Nova Cygni* 3 (1920). **K. G. Malmquist** and **J. B. Ohlsson.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 16. 25. pp. 1–12, 1922. In English.)—The observations were carried out at Lund Observatory during the year 1920. A Zeiss double refractor was used, its photographic telescope having a Petzval objective of 18-cm. aperture and 90-cm. focus. The photographic magnitudes were in most cases determined by utilising a series of comparison stars in the immediate vicinity of the Nova. During the first few days after its appearance, when it was too bright for this purpose, certain other suitable stars were photographed beside the Nova in the centre of the plate with an exposure of the same duration. The exposure was at first made with and without an object grating, and in each case with two or three periods of exposure. Afterwards, as the Nova became fainter, it was made only with the grating and, lastly, only one exposure of half an hour was made. The determination of the photographic magnitudes was effected by employing partly the diameters of the stellar discs which were obtained in the exposures without a grating and partly the central images of the exposures with grating. Each image was measured in two directions at right angles to each other, the mean of these two measurements being taken as the measure of the diameter. The magnitudes were then determined from a magnitude curve drawn for each photograph, taking the diameters of the comparison stars as abscissæ and their magnitudes as ordinates. In order to determine the effective wave-lengths a grating was placed in front of the objective. The position of the wires was always parallel to the diurnal motion, so that the spectra lay from north to south. The grating consisted of a row of parallel metallic wires of about 0·4-mm. gauge, and the intervals between them were as nearly as possible equal to their thickness. An accurate measurement gave the grating constant as $c = 0\cdot7985$ mm. The focal adjustment was $f = 899\cdot8$ mm. The effective wave-length was taken to be that wave-length in the spectrum which, for a given image, corresponds to the geometric centre of the spectrum. The micrometer of the measuring apparatus was employed in order to ascertain the interval *s* from centre to centre of the refraction spectra of the first order. The effective wave-length λc may be expressed by $\lambda c = \frac{c}{2f} \cdot s$. The authors' measurements appear to confirm those of Bernheimer at Upsala and Guthnick and Hügeler at Berlin-Babelsberg. The results are given in three tables and in a figure showing the photographic and the visual light curve, and also the magnitudes obtained by Tamm, Leavitt, Dyson, Luyten, Smart, and Green. E. F.

862. *Measures of Double Stars made with the* 10½-*inch Refractor of Minnesota University.* **F. P. Leavenworth.** (Astron. J. 34. pp. 151–155, Nov. 24, 1922.)—A repetition of measures of 83 well-known binary stars. The Right Ascensions and Declinations are for 1900, and the magnifying power 400. A. S. D. M.

863. *Star Fields for the* 1923 *and* 1925 *Solar Eclipses.* **F. Slocum.** (Astrophys. J. 34. pp. 148–150, Nov. 13, 1922.)—The solar eclipse of September 10, 1923, passes over Southern California and Northern Mexico; the eclipse is near noon, the sun's altitude over 60°, and totality over 3½ minutes. But the star field is poor. Plate I shows all the stars of magnitude 9·0 and brighter within 2° of the sun, and Table 1 gives the particulars of these stars, including the theoretical displacements on the basis of 1″·75 at the sun's limb. The total solar eclipse of January 24, 1925, passes over Vassar, Yale, Van Vleck, and Nantucket Observatories. The star field is better than in 1923, and Plate II and Table 2 give its particulars. A. S. D. M.

864. *Comparison of Standard Star Systems.* **R. H. Tucker.** (Astron. J. 34. pp. 143–147, Nov. 13, 1922.)—A comparison of Auwers' New System, which has been generally employed in the reduction of the Lick Observatory work, with the Old System of Auwers (derived about 25 years earlier), and with Lewis Boss's N.B.S., with Boss's Preliminary General Catalogue, and with Newcomb. The correction to Auwers' System at the equator is approximately + 0″·3; his declination is between those of Boss and Newcomb. The resulting correction to Boss at the equator would be + 0″·4, and that of Newcomb + 0″·1. A. S. D. M.

865. *Star of High Velocity.* **H. Shapley.** (Harvard Coll. Obs., Bull. 773 [2 pp.], 1922.)—RZ Cephei is a typical Cepheid of period three-tenths of a day; of photographic amplitude, eight-tenths of a magnitude; spectrum probably variable and of class Ao near maximum; proper motion, 0″·197 ± 0″·014 (Bull. Ast. Neth. No. 11. 1922); distance found at Harvard, 3800 light-years. Hence its transverse velocity is 1100 kilometres a second, the highest known. [See Abstract 463 (1923).] A. S. D. M.

866. *The Mass of Spectroscopic Double Stars.* **G. Abetti.** (Accad. Lincei, Atti, 31. ii. pp. 93–97, Sept., 1922.)—Applying the author's previous research [Abstract 2240 (1922)], Leonard (Publ. Astr. Soc. of Pacific, 33. p. 213, Aug., 1921), and Doig [Abstract 2242 (1922)], the author finds the ratio m_2/m_1 between the masses of certain binary systems. This ratio varies from 0·47 to 0·78. A. D.

867. *Masses of Visual Binary Stars.* **J. A. Miller** and **J. H. Pitman.** (Astron. J. 34. pp. 127–131, Sept. 1, 1922.)—Where trigonometric parallaxes of binary systems have been determined photographically, the components of the double are as a rule so near each other, that the combined images on the plates (taken at the Sproul Observatory, Swarthmore) are sensibly round, and in measurement the image is bisected. Does the revolution of the close pair change the shape of the image so as to vitiate seriously the determination of the parallax? In the case of 14 stars whose components differed by less than two magnitudes, 11 were altered by less than 0″·001, one by 0″·002, one by 0″·004, and one by 0″·009. It seems, therefore, that except in rare cases which can be avoided by examining the orbit, the error introduced by revolution is smaller than the error of measurement. In a table is given all binary systems contained in the Sproul card catalogue of parallaxes, whose orbits are known and whose parallaxes have been determined trigonometrically by one or more observers. These are divided into three groups, of which Group I contains 27 binaries of well-determined orbit, and accordant trigonometrical parallaxes, observed by two or more observers. Another table gives the average masses for the types as follows: B, 14·91; A, 3·49; F, 3·92; G, 1·77; K, 1·57; M, 0·65; the masses for the B-type being determined from photometric and spectroscopic orbits, and the other types from the first table, Group I. The authors urge that it is desirable to determine parallaxes by measure in some way, say by Wright's adaptation of the formula of Lehman-Felhes, and a table gives a list of 18 binaries (selected from the first table) whose absolute parallaxes might be determined in this way without inordinate expenditure of time and energy. A. S. D. M.

868. *Effective Temperatures of θ and ι Ursæ Majoris.* **C. Nordmann** and **Le Morvan.** (Comptes Rendus, 175. pp. 573–574, Oct. 9, 1922.)—The statement of the authors [see Abs. 1555 (1922)] that the effective temperatures of θ and ι Urs. Maj. are sensibly the same when deduced from the red and blue screens of the heterochrome photometer of the Observatory, was traversed by Hertzsprung in the Bulletin of the Astronomical Institute of the Netherlands (Sept. 29, 1922, No. 25), on the ground that the mean colour indexes of these two stars are sensibly different. The authors point out that the effective wave-lengths (wave-lengths of the centre of gravity of the luminosity curve of the star seen through the screen) are near 0·46 μ and 0·63 μ respectively, but the effective wave-lengths corresponding to the visual and photographic brightness (whose difference gives the colour index) are near 0·55 μ and 0·43 μ. The relative intensities of the stars may therefore be different for these different regions; indeed, they are very different for the blue and green screens, and here resemble the difference of colour index. Abbot has shown that the effective temperature of the sun differs notably when deduced from the relative intensities of these or those spectral regions; the same may hold good for stars. A. S. D. M.

869. *Jupiter's Satellites VI, VII, and VIII, and Phœbe.* **G. van Biesbroeck.** (Astron. J. 34. pp. 167–168, Dec. 18, 1922.)—Photographs were taken, with the 24-inch reflector of the Yerkes Observatory, of the fields containing faint satellites, the guiding eyepiece being shifted according to the estimated motion of the satellite; the plates were obtained in pairs, and the moving objects recognised without too much difficulty by means of the blink-comparator. In measurement, the satellite was referred to three neighbouring stars of the 11th or 12th magnitude, whose positions were deduced from astrographic plates taken at Uccle in Belgium, and measured on the same machine. A list of the measures is given, and the corrections to the elements in the American Ephemeris for 1922. No attempt was made to photograph Jupiter IX, as this would have left no time for other objects. A. S. D. M.

870. *Some Relations in Stellar Statistics.* **K. G. Malmquist.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 16. No. 23. pp. 1–52, 1922. In English.)—In stellar statistics there are three fundamental functions; the distributions of the apparent and absolute luminosities of the stars and their density distribution. Instead of the luminosities, magnitudes, apparent or absolute, may be used; the absolute magnitude of a star is defined as its apparent magnitude at unit distance which is 10^6 times the mean distance of the earth from the sun (one siriometer). A stellar year is 10^6 times a tropical year. To get the corresponding absolute magnitude when a parallax of $0''\cdot 1$ is taken as unit distance, add $1^m\cdot 57$. The author showed in "A Study of the Stars of Spectral Type A," that for a given spectral type, if it may be assumed that the relative frequency curve is a normal error curve, it is possible to deduce some relations between the entering constants, which relations are valid irrespective of the form of the density function $D(r)$, which contain only that part of $a(m)$ [the frequency function of m, the apparent magnitude] which is directly observed. The present paper is an extension of the relation given in his earlier paper, and it is throughout assumed that there is no appreciable absorption in space, that the frequency function of the absolute magnitude is a normal curve of type A, and that this function is independent of the distance of the stars. The author shows that if the fundamental constants M_0 (the mean value of M the absolute magnitude) and σ (the dispersion) are the same over the whole sky for a given spectral type, that the relations given are valid for an arbitrary area of the sky, independent of an eventual variation of the density-distribution within the area in question. He gives examples of how to form, from the mean parallax, relations between M_0 and σ equivalent to those deduced from the mean reduced parallax, for 524 non-galactic stars, for 910 galactic stars, and for 1434 stars brighter than the 6th apparent magnitude. A. S. D. M.

871. *Parallaxes of Seventy-Two Stars.* **J. A. Miller** and **J. H. Pitman.** (Astron. J. 34. pp. 119–121, Aug. 18, 1922.)

872. *Parallaxes of* 102 *Stars.* **S. A. Mitchell.** (Astron. J. 34. pp. 135–138, Sept. 12, 1922.)

873. *Second Order Terms in Differential Aberration and Stellar Parallax.* **W. M. H. Greaves.** (Roy. Astron. Soc., M.N. 83. pp. 60–63, Nov., 1922.)—The effect of neglecting these terms in parallax determinations is considered. A straightforward geometrical investigation leads to the conclusion that the error thus introduced is limited by $\delta\pi < \gamma_0\rho^2/f_1 - f_2$ where γ_0 is the constant of aberration, ρ the mean distance of the comparison stars from the parallax star and f_1, f_2 the parallax factors for the parallax and any comparison star. Taking $\rho = 20'$, $f_1 - f_2 = 1 \cdot 5$, and $\gamma_0 = 20'' \cdot 4$ gives $\delta\pi < 0'' \cdot 0005$. With present standards of accuracy such an effect may be neglected. A. Wh.

874. *Atmospheric Dispersion and Photographic Determinations of Stellar Parallax.* **C. Davidson and W. M. H. Greaves.** (Roy. Astron. Soc., M.N. 83. pp. 56–60, Nov., 1922.)—If two plates in a series intended for parallax determination be taken at hour angles t and t_0, and the atmospheric dispersion be neglected, there is a residual error $n(t - t_0)$ where n is related to the coordinates of the plate. If z is the zenith distance, λ the co-latitude, and $\delta\beta$ the difference in the coefficient of refraction for the parallax and comparison stars, $n = 0 \cdot 0044 \sec. z . \sin \lambda . \delta\beta$. If R be the total residual for any plate, the least square solutions of $f\pi + t\mu + c = \mathrm{R}$ will give the parallax, π; the proper motion, μ; the parallax and time factors, f and t, and a constant, c. If R is not assumed to include dispersion error, the values of π and μ will be incorrect. The equations to be solved should be $f\pi + t\mu + c = \mathrm{R} - n(t - t_0)$. Tables of spectral type and effective photographic wave-length and hence $\delta\beta$ are given, assuming that the mean effective wave-length of the comparison stars is λ4370. Hence the parallax error for an unfavourable case is worked out and is found to vary from $-0'' \cdot 0091$ for Class B to $0'' \cdot 0058$ for Class K_5, when $t - t_0 = 20^m$, $f - f_0 = 1 \cdot 5$, $\lambda = 38° \; 31'$ (Greenwich) and $z = 30°$ for a reflector. The error introduced by neglecting dispersion is appreciable, but correction is uncertain owing to lack of data on the effective wave-lengths. The best solution seems to be to work on the meridian as closely as possible. A. Wh.

875. *Spectroscopic Parallax of the Hotter Stars, especially of Class B.* **D. L. Edwards.** (Roy. Astron. Soc., M.N. 83. pp. 47–55, Nov., 1922.)—A large number of spectrum photographs of stars of various types are examined and the intensities of certain lines compared by a wedge method with the hydrogen lines as standards. The intensities are then examined to detect systematic variations with spectral type or absolute magnitude. If any line shows variation, it is recompared with apparently unaffected lines in its vicinity. Such variable lines are plotted against (*a*) type, (*b*) absolute magnitude. Hence further stars can be readily classified, and their absolute magnitude estimated. The lines used for classification are λ4472, 4026, and 4481, and for parallax 4388, 4144, and 4009. A preliminary list of results applied to stars of Class B shows the possibilities of the method and its comparison with hypothetical and some trigonometrical determinations. A. Wh.

876. *Radial Velocities of 25 N Stars.* **J. H. Moore.** (Lick Observat. Bull. 10. No. 342. pp. 160–168, 1922.)—Class N spectra have great complexity, containing both absorption and emission lines (of which last, only those due to hydrogen have been identified), and hitherto only for 8 stars have radial velocities been published (by Hale, Ellerman and Parkhurst). The above 25 N stars are those whose spectra have been successfully photographed in the region 4340–4800A with a one-prism spectrograph attached to the 36-inch refractor of the

Lick Observatory. As the colour index of N stars is about two magnitudes, it has been necessary to confine the observing to visual magnitudes brighter than the 7th, and the available stars, 50 in number, have been cut down to a half, as N stars are irregularly variable, and there is considerable difficulty in securing observations of such as attain the 7th magnitude only at their maximum. Good spectrograms were obtained of 19 Piscium, Y Canum Venaticorum, and U Hydræ, and from these were selected two plates, one of 19 Piscium and one of U Hydræ, to be used as standard reference plates in measuring. Two satisfactory spectrograms at least were obtained for 23 of the stars, and an extra number were taken of the brighter N stars, for investigating the possibility of variability in the radial velocities, and some evidence of this was found in the case of 19 Piscium, Y Canum Venaticorum, and U Hydræ. A table gives the data for the 25 stars, of which the 5th column shows the author's estimate as to whether the star belongs to class N_a or N_b. Another table gives the comparison for 8 stars, measured by Hale and his colleagues. The author finds a value for the position of the apex, the solar velocity, and the error term K (R.A., 225°; Dec., + 11°; V, − 17·1 km./sec.; K, + 6·8 km./sec.). He considers them of little value since few stars are employed, but points out that the value of the solar velocity is smaller than that (19·5 km./sec.) found by Campbell from the radial velocities of 1193 stars. The position of the apex is some 60° distant from the general position given by all stars (R.A., 270°; Dec., + 30°), and as far as this determination goes, it suggests that the N stars are moving as a separate group. From the proper motions of 78 N stars, Luplau-Janssen and Haarh found for the apex, R.A., 95°·5, Dec., + 68°·5. From the radial velocities of 23 of the stars and from their proper motions (got from various sources), the mean parallax is found as 0″·0032, and the corresponding mean absolute magnitude is − 1·5, which is in good agreement with that found by Luplau-Janssen and Haarh. The stars of class N have a mean absolute magnitude greater than those of class B. A. S. D. M.

877. *Minor Planet Photographs in* 1921 *with the Franklin-Adams Camera.* **H. E. Wood.** (Union Obs. of S. Africa, Circ. 55. p. 138, May 16, 1922.)—Observations of: 1921 JS (new); 896 1918 DV; 117 Lomia; 61 Danæ; 925 Alphonsina; 33 Polyhymnia; 446 Æternitas; and 224 Oceana. A. S. D. M.

878. *Spectral Constitution of the Nearer Parts of the Milky Way.* **H. Shapley.** (Harvard Coll. Obs. Circ. 240. [6 pp.], 1922.)—A statistical discussion of 11,030 stars, brighter than magnitude 8·25, in selected fields along the Milky Way and between galactic latitudes + 10° and − 10°. The centres and boundaries of these fields, and the number of stars in each separate class in different longitudes are given in tables. There are also figures showing the distribution of stars of all spectral classes combined, for three different belts of galactic longitude; and the distribution along the Milky Way in the three belts (+ 10°, 0°, − 10°) for various spectral classes of stars between magnitudes 7·00 and 8·25; here proportions are used and not numbers of stars. The latter figure shows the galactic concentration; particularly for classes B and A in the mid-belt. The local system is probably responsible for the greater number of B and A stars in southern galactic latitudes. In this figure, 38 per cent. of the stars are of class A, and 29 per cent. are of class K, so that these two classes definitely predominate at a distance of between 100 and 500 parsecs in so far as stars of the ordinary catalogues are concerned (dwarf K stars in this region would be of the 12th apparent magnitude). There is a deficiency of A and K stars of magnitudes 7·00 to 8·25 in the region of the Taurus nebulosities, but the brighter A and K stars do not show this, and classes F and G are unaffected. It follows that F and G stars, between these magnitudes (7·00 to 8·25), are dwarfs and that a large number of the K stars are giants. Assuming an absolute magnitude of + 1·0 for these A and K stars, occulted by the clouds, the distance of the obscuration comes out as not greater than 250 parsecs. The great Milky Way rift between longitudes 340° and 20° comes out in both figures. The comparatively near star clouds in Cygnus seem to affect appreciably class A stars only, and the class B stars alone show the richness of the Carina region. One of the striking results is the uniformity (except for the above-mentioned exceptions) in the galactic distribution of all spectral classes except M. Deeper in space, this does not hold. A. S. D. M.

879. *Red Stars and their Relation to the Spectral Series.* **W. Gyllenberg.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 16. No. 24. pp. 1–56, 1922. In English.)—In the first two chapters the author discusses our present knowledge of the different spectral classes; he gives definitions of units of length employed; the relation between colour index and the spectral classifications; a determination of the solar velocity, and a comparison of the mean value of $1/r$ for stars brighter than the 5th and 6th magnitudes respectively. In passing from the 5th to the 6th magnitude, there is a fall in density for the bright giants, but not appreciably for the dwarf stars. The author discusses the colour index determinations of classes, N, R, and Md, and compares for classes A to Md the mean colour obtained by Krüger with the corresponding colour index. The R stars are also partly included in Krüger's catalogue. He gives a table of the proper motions of Secchi's Class IV, and discusses the proper motions of the N stars included therein; though the mean errors of these are high, results seem to show that the N stars give a higher value for the declination of the apex than the brighter stars of other spectral classes, the difference between the two positions amounting to about 26°. Using the solar velocity of the class M stars ($S = 4{\cdot}43$ siriometers), the mean for $1/r$ for stars of type N comes out as $0''{\cdot}0015 \pm 0''{\cdot}00066$; and the value of R (the distance in siriometers, of a star whose magnitude at maximum is equal to zero) is the largest found for any spectral class; the corresponding absolute magnitude is $-4{\cdot}14$ (at unit distance of one siriometer). The N stars are a homogeneous group of giant stars, and their mean luminosity is of the same magnitude as that of the Wolf-Rayet or of the helium stars. In Table 3, there are given the values of R and of the mean absolute magnitudes for each spectral class; for classes Oe5–K5 for all stars brighter than the 6th apparent magnitude; for Ma–Mb stars, brighter than the 5th; and for Md and N stars, brighter than the 9th. The variation of the mean absolute magnitude is possibly caused by the presence of dwarf stars. The O and the B stars are all giants, and the decreasing brightness when passing through the spectral series is due to the increase in the relative number of dwarfs, but among the latest spectral classes, Md and N, there are probably none of these. The brightness of the giant stars of the highest and lowest temperatures is approximately the same and cannot differ much from magnitude, -3 or -4. The author obtains the density of the stars per cubic siriometer in the vicinity of the sun as follows: for class O, 0·00002; B, 0·0023; A, 0·018; F, 0·112; G, 0·012; K, 0·018; M, 0·0009; Md, 0·00005; N, 0·000001. Of 20,000 stars, in general there should, upon an average, be one star of spectral type N. Table 6 is a catalogue of 210 N stars for obtaining their distribution in space, and three diagrams give the distribution of these stars in the plane of the Milky Way and in two planes at right angles to it and to each other. The pole of the galaxy as defined by the distribution of the N stars is $\delta = 12^{\circ}\,59^{m}\cdot 2$, $\delta = 28^{\circ}\cdot 39$, and the N stars are symmetrically distributed about the galactic plane. A diagram gives the thickness of the Milky Way as derived from the different spectral classes. The cooler giant stars have a large extension in space, the hotter giants are clustered near the centre of the stellar system. A. S. D. M.

880. *Absence of Oxygen and Water-Vapour Lines from the Spectrum of Venus.* **C. E. St. John** and **S. B. Nicholson.** (Mt. Wilson Obs., Contrib. No. 249. Astrophys. J. 56. pp. 380–399, Dec., 1922.)—From spectrograms taken at Mt. Wilson, the authors have found, when the relative velocity of Venus and the Earth was such as completely to separate the corresponding lines produced by the two atmospheres, that no trace of any line was observed either of oxygen or water-vapour, as due to Venus. In the path traversed by the solar beam through her atmosphere, there must be less than the equivalent of 1 m. of oxygen, less than 1/1000 of that in our atmosphere, and less than 1 mm. of precipitable water-vapour. The authors discuss whether reflection on Venus takes place at the upper surface of a 4100-ft. haze bank which may be partially cut off at times by low mountains, and is therefore close to the actual surface, as suggested by Russell; or from heavy cumuli and filmy cirrus, some 43 km. above the real crust, as suggested by Clayden. Since any conclusion as to water-vapour must rest upon the nature and temperature as well as the apparent surface at which diffuse reflection takes place, they discuss for Venus, her albedo, rotation, average temperature, and the relative height on the earth and Venus at which maximum cloudiness should take place were Venus similar in atmosphere to the earth. In this connection they study the increase of humidity at Mt. Wilson, when the "high fog," 4000 ft. below in the valleys, is present, over the humidity when the fog is absent. The general conclusion is against Clayden's heavy cumulus cloud layer. They suggest a hazy atmosphere on Venus, somewhat like dry-weather haze, and that under the extremes of temperature on the opposite hemispheres, there may be great and permanent dust storms, the dust being of highly reflective material such as that to which the brightness of Vesta is due; evidence on this point might be obtained from the relative colour-indices of Venus and terrestrial clouds, and by direct photographs through violet and infra-red filters. A. S. D. M.

881. *Anomalous Dispersion in Stellar Spectra.* **M. Maggini.** (Comptes Rendus, 175. pp. 1393–1395, Dec. 26, 1922.)—The author draws conclusions from his researches on the effect of anomalous dispersion in certain spectral doublets [see Abstract 453 (1923)]. It should be possible to predict the phenomena presented by radiations from the lower photospheric layers of a star which traverse calcium clouds overlying, or such as lie in intervening space. The author suggests the scrutiny of large dispersion spectrograms of B-type stars for lines near the triplets of magnesium, or calcium, or the doublet of sodium, for variation as compared with the behaviour of other lines of the same series. He draws attention to the behaviour of the lines 4481 and 4352 of magnesium. 4481 is strong in Sirius, Procyon, and Vega, and feeble in the sun and in types F and G generally, and almost disappears in K- and M-stars. 4352, on the other hand, is only found in late types; it is strong in the sun and Alpha Orionis (Ma-type). His experience is that it is possible to ascertain what the dispersion near 4352 may be, but not that near 4481. A. S. D. M.

882. *Stellar Spectra of Class S.* **P. W. Merrill.** (Mt. Wilson Obs., Contrib. No. 252. Astrophys. J. 56. pp. 456–474, Dec., 1922.)—Secchi's types III and IV, due to titanium oxide and carbon respectively, are classed at Harvard College Observatory as M and N. No object is known to show both titanium and carbon bands, these spectral features seeming to be mutually exclusive. The N stars do not seem to come in the spectral progression, B, A, F, G, K, M, but form a side branch together with the R-stars (G–R–N) parallel to the main portion G–K–M. Among the long-period variables are several which are not clearly either M or N; they resemble in type R Cygni and R Lyncis; and have been given S as a class name. Table I gives a first list of 17 such stars with descriptive notes. In general the S stars are more closely related to giant Ma stars than to other types. Their most characteristic feature is a complicated structure in λλ4630–4660, consisting both of absorption and emission lines. In continuous spectrum the stars are red, the colour-indices being about as great as for the Md variables, namely, 1·8 magnitudes. There are bright hydrogen lines, as in M variables, but the lines have quite different properties; in S, the less refrangible lines are stronger, rapidly decreasing in intensity towards the ultra-violet. In some S spectra, Hζ is stronger than Hε, as is also true in Md stars. An unexpected feature is the presence of the enhanced lines of iron, λλ4584, 4924, 5018. The mean period of 16 S stars is 364d, resembling the advanced Md stars. It seems probable that S stars form a third division of the giant sequence, and that they are more closely related to M than to N stars. Along each of the three branches M, N, and S, there is an increasing tendency towards variability in light, and towards the presence of bright lines in the spectra. A. S. D. M.

883. *Note on Ionised Calcium.* **H. Shapley.** (Harvard Coll. Obs., Bull. 767 [2 pp.], 1922.)—Stationary H and K lines have been noted in the spectra of first-type binaries and attributed to their gaseous envelopes. This might act as a resisting medium. Miss Maury has examined β Aurigæ and ζ Ursæ Majoris of periods 3·96 and 20·5 days respectively, and finds that the first shows a difference in the appearance of the spectral K-line for the front and back side of the surface, but that the second binary shows none; and for the first, Baker finds a suggestion of a lengthening period, but none for ζ Ursæ Majoris. [See Abstract 453 (1923).] A. S. D. M.

LIGHT.

884. *Direct Reading and Computing Attachment for Sphere Photometers.* **B. S. Willis.** (Am. Illum. Eng. Soc., Trans. 18. pp. 62–66, Jan., 1923.)—Describes a modification of the computing scales used at the Bureau of Standards [see Abstract 1134B (1915)] in connection with the measurement of vacuum lamps on life test. When lamps are measured in the integrating sphere it is not possible to use a fixed comparison lamp and move the photometer head; in this case the photometer head has to be fixed while the comparison lamp is moved, with the result that the candle-power scale on the bench departs markedly from a logarithmic form. Described and illustrated in the paper is a cam and gear arrangement by which the differences between the inverse square scale and the logarithmic scale are automatically taken up by the motion of the scale of reference of the computer. The results of tests shown tabulated in the paper indicate that an accuracy of 0·2 % has been attained.

J. W. T. W.

885. *New Optical Lecture Experiments.* **F. P. Liesegang.** (Phys. Zeits. 23. pp. 552–553, Dec. 15, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—A series of experiments demonstrating various interference phenomena by means of the Classen interference apparatus.

E. F.

886. *On the Theory of the Kerr- and Faraday-Effects.* **K. F. Herzfeld.** (Ann. d. Physik, 69. 5. pp. 369–384, Dec. 12, 1922, and 70. 4. p. 322, Feb. 22, 1923.)—The Kerr-effect, that transparent isotropic bodies under the influence of strong electric fields exhibit double refraction, has been the subject of many theories, all based upon classical electrodynamics and mostly very complex. The present paper examines the problem from the standpoint of the quantum theory, and particular attention is given to the inverse proportionality of the effect on the square of the electric field, *i.e.* the Kerr constant $j = (n_z - n_x)/\lambda E^2$, where n_z and n_x are the respective refractive indices, λ the wave-length, and E the strength of the homogeneous electric field. The same method is then applied to the Faraday-effect, *i.e.* the plane of polarisation of linear polarised light is rotated by many transparent bodies when subjected to a strong magnet field whose lines of force run parallel to the direction of propagation of the light. Section 1 is devoted to the theory of the Kerr-effect, Section 2 to a comparison with experience, and Section 3 to the related Faraday-effect. The investigation is made from two standpoints: (I) The dispersion theory, by which a connection is sought between the refractive index and the position and strength of the absorption strips. (II) The theory of the Stark-effect, by which the influence of the external field on the absorption strips is derived. The various theories only differ in that they assume either a Stark-effect of the usual kind upon the single molecule, or different changes in intensity for similar directions of the molecules for different directions of polarisation, or finally on influence of the reciprocal effects of neighbouring molecules. Experiments do not as yet permit a clear decision between the theories. The Faraday-effect may be regarded as the influence of the Larmor precession of the molecules upon the refractive indices. The paper also gives the formulæ for the longitudinal Kerr-effect. H. H. Ho.

887. *Interference Method for Testing an Optical System.* **E. Bratke** and **E. Waetzmann.** (Zeits. f. Physik, 12. 5. pp. 253–257, 1922.)—Describes a development of Waetzmann's method for finding the imperfections of an optical system by means of the interference pattern formed when a mirror is placed in the position of the focal plane [see Abstract 395 (1913)]. J. W. T. W.

888. *Corona.* **A. Draault.** (Comptes Rendus, 175. pp. 1400–1402, Dec. 26, 1922.)—In the accepted theory of the corona, the effects of the individual grains are supposed mutually to compensate one another, so that the resultant amplitude is equivalent to that which would be produced by one grain, multiplied by the number of grains. Consequently the diffraction rings observed should be independent of the distribution of the grains. The author has obtained results which disprove this, using separately lycopodium powder, diameter 29,5 μ, red corpuscles from human blood, dried on glass, 8 μ, and spores from rusted wheat, 15,3 μ. With the blood corpuscles, the central disc seen through red glass is slightly brighter at the edge than in the centre, while with green glass it is certainly more luminous at the periphery. On the accepted theory, the centre should be brighter, so that a maximum exists not contemplated by the theory.

The dry rust spores dusted on a piece of glass exhibit no difference from the lycopodium corona, except in point of size, but if the spores are first moistened with distilled water, and are then put to dry on the glass, the central disc is found to be considerably modified. At its edge is now found a new ring showing the spectral colours, red outside, and green inside, and within the green the disc is practically black.

Examination with a microscope shows that the only difference is in the arrangement of the grains: in the preparations which give the new ring, the grouping of the particles is more regular. The ordinary centre is produced when the grains are at unequal distances apart, and the new ring when the distance between the particles is nearly constant. Measurement of the diameter of the new ring shows that it is inside the theoretical first minimum. A difference between the central ring and the peripheral rings can be observed if a preparation on glass is held vertically and rotated about a vertical axis, as this causes the horizontal separation of grains apparently to shorten, and so the ring dependent on intergranular distance is distorted. A. C. M.

889. *Quetelet's Rings in Mica.* **N. K. Sethi** and **C. M. Sogani.** (Indian Assoc. for Cultivation of Science, Proc. 7. 3 and 4. pp. 61–74, 1922.)—When a distant source of white light is viewed by reflection at a sheet of mica of which the front surface is covered by a thin translucent film, the image of the source appears surrounded by brightly coloured rings which are intensified by silvering the back of the mica. The phenomenon is of the same nature as the Quetelet's rings exhibited by a dimmed mirror. The effects due to double refraction in these rings in mica have been studied in detail by the authors, who put forward a theoretical explanation. It is shown that there are four independent sets of Quetelet's rings nearly elliptical in form, instead of the single set of circular rings in isotropic media, and the interaction of these give rise to two systems of curves of minimum visibility. One of these systems of curves is fixed relatively to the mica and is the same as that observed in Haidinger's rings in the same plate. The other system as well as the first consists of lemniscates with the same poles as the fixed system, but the size and positions vary as the direction of incidence is altered. When the two systems are out of step an additional line of dislocation is also observed. This runs nearly along an isogyre and is seen in the neighbourhood of the optic axis. When the incident light is polarised or when the rings are viewed through a nicol the appearance is different and in general only very small portions of the curves are visible. But when the incident light is polarised and the observations are also taken through a nicol, certain dark curves are got and an isogyric line in place of the usual bright curves of minimum visibility, the whole appearance resembling that observed with crossed nicols in convergent light.

The paper is illustrated by plates and figures of the phenomena observed. J. J. S.

890. *Caustics Formed by Diffraction.* **P. Das.** (Calcutta Math. Soc., Bull. 13. pp. 35–46, June–Sept., 1922.)—Discusses mathematically the caustics found by Raman and Mitra in the case of diffraction plates of the Fresnel class. J. W. T. W.

891. *Molecular Scattering of Light in n-Pentane.* **R. Venkateswaran.** (Chem. Soc., J. 121. pp. 2655–2663, Dec., 1922.)—This paper is a contribution to that field of work in physical chemistry which was opened up by the researches of Smoluchowski, Cabannes, and Lord Rayleigh, on the molecular scattering of light in gases and vapours [Abstract 431 (1915)]. The theory of molecular scattering of light was developed by the late Lord Rayleigh, and according to this α, the fraction of the incident energy which is scattered in passing through unit volume of the substance, is given by the formula

$$\alpha = \frac{32\pi^3}{3}\frac{(n-1)^2}{N\lambda^4}$$

where N is the number of molecules per unit volume, n the refractive index of the medium, and λ the wave-length of the incident light. The measurements of Cabannes and Rayleigh are in general agreement with the late Lord Rayleigh's theory. Of a higher order of magnitude is the phenomenon of opalescence exhibited by substances in the neighbourhood of the critical state. An explanation of the phenomenon on thermodynamic principles was brought forward by Smoluchowski, and Einstein obtained from Maxwell's equations of the electromagnetic field an expression for the intensity of the light scattered in consequence of accidental deviations of density. According to this the fraction, α, of the incident energy scattered in the substance per unit volume is

$$\alpha = \frac{8\pi^3}{27}\,RT\beta\,\frac{(n^2-1)^2(n^2+2)^2}{N_1\lambda^4}$$

where R is the gas constant, N the Avogadro number, β the isothermal compressibility of the substance, n the refractive index, and λ the wave-length of the incident light [Abstract 815 (1911)]. The subject has since been investigated by C. V. Raman, who has shown that the three phenomena are closely related and has given a correction of the Einstein-Smoluchowski theory [see the two following Abstracts]. The present paper gives an account of experiments on the scattering-power observed in the case of *n*-pentane. The results show a satisfactory agreement with the Einstein-Smoluchowski formula and indicate that the Rayleigh formula requires to be changed. The investigation of the polarisation of the light scattered supports the theory developed by Raman and a correction factor has to be introduced. The total intensity of the scattered light in the direction transverse to the primary beam is increased in the ratio $(6 + 6r)/(6 - 7r)$. The quantity r which is a measure of the imperfectness of polarisation being given by the expression

$$r = \frac{\text{Intensity of weak component}}{\text{Intensity of strong component}}.$$

Complete tables of the experimental results are given. J. J. S.

892. *Molecular Scattering of Light in Dense Vapours and Gases.* **C. V. Raman** and **K. R. Ramanathan.** (Phil. Mag. 45. pp. 113–128, Jan., 1923.)—The paper deals with the problem of the molecular scattering of light in dense vapours and gases not obeying Boyle's law. (1) It is shown that the Rayleigh law of scattering, which is based on the assumption of a random distribution of the molecules in space, should not be applicable in these cases. (2) Assuming the non-random distribution of the molecules in space to be given by Boltzmann's theorem, a calculation is made of the scattering power of the medium, the result being interpreted with the aid of the virial equation. It is shown that the scattering power per unit volume is proportional to the absolute temperature, to the square of the density of the substance, and to its compressibility. If the gas obeys Boyle's law the expression reduces to the Rayleigh law. (3) The result thus deduced directly from the principles of the kinetic theory agrees with the general formula derived from the thermodynamical theory of density fluctuations developed by Einstein and Smoluchowski. (4) Experiments carried out with ether vapour and liquid over a wide range of temperature, both below and above the critical point, confirm the Einstein-Smoluchowski formula for this substance. (5) Consideration is given to the corrections of the formula required owing to the incompleteness of the polarisation of the transversely scattered light, and also to those necessary in the immediate neighbourhood of the critical point when the compressibility becomes excessively great. (6) Reference is made to the cases of carbon dioxide and of the permanent gases, and the possible significance of the results got in these cases is discussed. (7) Later experiments were carried out on the light-scattering which occurs in the vapours of benzene and pentane at different temperatures and carbon dioxide was examined at high pressure when contained in sealed bulbs. These experiments confirm the Einstein-Smoluchowski formula and show that the Rayleigh law of scattering only applies to gases obeying Boyle's law. J. J. S.

893. *Molecular Scattering of Light in Liquid Mixtures.* **C. V. Raman** and **K. R. Ramanathan.** (Phil. Mag. 45. pp. 213–224, Jan., 1923.)—

Many substances, such as phenol and water, which in the liquid state dissolve each other completely and form a single phase above a certain temperature, below it are only partially soluble and divide into two co-existent phases. Such mixtures show a marked opalescence or turbidity at temperatures a little above that at which they separate into two layers. Smoluchowski has investigated the phenomenon, and it has also been treated by Einstein [Abstract 815 (1911)]. In the present paper the approximate investigation of the scattering of light in liquid mixtures given by Einstein is revised, and a rigorous formula is developed in which account is taken of the compressibility of the mixture. It is shown that the thermodynamical investigation leads to the result that the light-scattering arises in two distinct ways: (1) due to spontaneous local fluctuations in the composition of the mixture, and (2) due to local fluctuations of its density. Einstein's approximate investigation ignores the second effect, which becomes very important when the observations are made at temperatures not close to the critical solution point or in the case of liquids which are completely miscible at ordinary temperatures. The scattering power is expressed in terms of the compressibility of the mixture, and the variations of its refractive index and the partial vapour-pressures of its constituents with the composition. A discussion is given of the effects of molecular anisotropy, which gives rise to an additional "orientation-scattering." It is shown that the polarisation of the transversely scattered light is imperfect as the result of molecular anisotropy, but it is considerably less so in the mixture than in the pure liquids, and it becomes more and more perfect as the critical solution temperature is approached. A comparison of the theoretical results with the available experimental data shows a general agreement. Similar methods may be applied in the case of solutions of solids in liquids, and in the case of ternary mixtures. J. J. S.

894. *Prismatic Dispersion.* **H. Opitz.** (Zeits. f. Physik, 12. 5. pp. 304–314, 1922.)—A further contribution to the study of the geometrical optics of prism dispersion, with special reference to previous work by Erfle [see Abstract 650 (1923)]. J. W. T. W.

895. *Absorption of Light by Chlorine.* **H. v. Halban.** (Zeits. Elektrochem. 28. pp. 496–499, Dec. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—The absorption is very small for all rays. With the aid of their compensation arrangement of two photoelectric cells (used as zero instrument), a rotating sector, and a wedge (Zeits. phys. Chem., 100. pp. 208–230, 1922), the author and K. Siedentopf explore the range 254 $\mu\mu$ to 643 $\mu\mu$, taking the chlorine from steel cylinders, or specially-prepared chlorine. It is found that chlorine absorbs, though very feebly, in all parts of the spectrum, the extinction coefficients being 0·239, 7·39, 65·5, 1·636, 0·1263, 0·00172, 0·0003, 0·049 for λ254, 280, 334, 436, 496, 546, 579, 614 $\mu\mu$. A layer 84·7 cm. in thickness absorbed only 1·5 per cent. of the light near λ546. No particular features were observed in the range λ380 to 450 which corresponds to the heat of dissociation of the chlorine molecule and for which peculiarities had been suggested. Moist chlorine absorbs nearly 1 per cent. less than dry chlorine; probably the chlorine concentration in the gas is smaller in the presence of water. H. B.

896. *Influence of Ionic Adsorption on the Photochemical Sensitivity of Silver Bromide.* **K. Fajans.** (Zeits. Elektrochem. 28. pp. 499–505, Dec. 1, 1922. Paper read at Deut. Bunsen Gesell., Sept., 1922.)—Vogel recognised in 1863 already that the sensitivity of AgBr to light varies with the conditions under which it is precipitated. According to Lottermoser the sols become in this precipitation electropositively charged when there is an excess of silver nitrate, and negatively with an excess of potassium bromide. The Ag ions are adsorbed by the surface of the silver bromide and render it positive, and a so-called "silver-body" (and an analogous bromine-body) is formed. That there is such an adsorption of Ag ions is shown by titration experiments; more than the theoretical amount of silver nitrate is wanted before the dichromate indicator responds; ultramicroscopical counting of the disperse particles supports these experiments. According to the authors the primary effect of light on silver bromide now consists in the transference of an electron from a bromine ion to a silver ion, under formations of neutral atoms of Br and Ag, and the work to be done in this transference is smaller when the electron joins an adsorbed silver ion than when it passes to a normal silver ion in the bromide surface. In the sense of Einstein's law that would mean that it should be possible to effect the formation of the neutral atoms with a smaller $h\nu$, *i.e.* with light of greater wave-length. To demonstrate this it is necessary to prevent, so far as possible, the spontaneous reunion of the Ag and Br atoms (separated by the light) by adding acceptors for the bromine to the preparation. Experiments are made with silver bodies containing as acceptor an excess of silver nitrate; with pure dry silver bromide in a vacuum using mercury-vapour as acceptor; and with bromine bodies in sulphuric acid and phenylpropiolic acid; as source of light the spectrum of a 3000-candle Osram "Nitra" lamp is used, filtered through various media. By these means it is shown that the smaller energy of light of 620 $\mu\mu$ (and more) suffices to decompose a silver body, while light of less than 435 $\mu\mu$ is required to decompose a bromine body or pure silver bromide. Further, in red light the darkening of the bromide stops at the grey tone, while orange light then causes a further darkening. Thermochemically 111 cal. are required to decompose AgBr, photoelectrically 67 cal. suffice; that may be because the energy in the latter case is smaller by the heat of the adsorption of the silver particles. H. B.

897. *Actinic Brightness of Light Sources.* **A. Köhler.** (Zeits. Instrumentenk. 42. pp. 349–367, Dec., 1922.)—The author develops the formulæ in actinic or chemical radiation from a source, analogous to those used in ordinary photometry. He uses as his unit the actinic radiation power of a Hefner lamp. The actinic illumination (irradiation) is measured by means of sensitive paper using a modified Schwarzschild law to connect density with exposure (radiation × time). From the value of actinic irradiation thus found the actinic brightness of the source is calculated. The effect of introducing diffusing media in the path of the radiation is considered, and illustrated by detailed treatment of two examples. J. W. T. W.

898. *Effect of Light on Zinc Sulphide.* **P. Lenard.** (Ann. d. Physik, 68. 7 and 8. pp. 553–573. Oct. 4, 1922.)—In the numerous experiments in which phosphorescent bodies have been subjected to illumination for long periods, only one case of actual change has been noticed as a direct light effect and this for zinc sulphide which was darkened. This work was carried out by Hausser [see Abstract 555 (1910)], and further work by the present author, which had hitherto been unpublished, is now forthcoming because of some recent results by Millikan which appear to indicate important developments for the elucidation of the mechanism of phosphorescence. It would appear that the darkening of zinc sulphide by light arises from molecular disruption in like manner to known chemical photo-effects, whereby the zinc union is loosened as is the silver in silver iodide. Should the phosphorescence property depend on the heavy metal content, then darkening should be accompanied by a different spectral distribution. This lack of agreement in the spectra appears to occur. Zinc sulphide, however, easily forms complex molecules with increasing temperatures which may act as phosphorescence centres; while, in contrast to silver haloids, it requires the presence of water for the photo-darkening effect and moreover shows a tendency to pass easily again into its original odourless condition in a manner not to be anticipated from the usual chemical considerations. Chemical influences have been investigated and the experiments are fully described. In the absence of light, neither NH_3 nor $H.CHO$ produce darkening, although promoting the same in its presence. Ozone inhibits the effect. It was found that the ordinary zinc sulphide molecules do not exhibit the photo-effect unless a pre-heating has been made, when the substance becomes very sensitive to light. This points to a polymerised molecule as the phosphorescence centre; a conclusion supported by the inhibiting effect of pressure. Experimental details with respect to spectral distribution are described at length. Work with a large number of other phosphorescent substances is also published for comparison purposes, *e.g.*, the alkaline earth sulphides, boric acid phosphors, etc. Experiments are also described for phenanthrene. The depth of the dark layer has been examined by methods involving its removal by means of chlorine, ammonium sulphide vapour, etc., but the opinion is formed that such oxidation agents function as catalysts in the regeneration process. The paper concludes with a discussion of the function of water, since its presence is an essential feature for the photo-effect. The fact that the quantity of water necessary is far in excess of an amount for catalytic purposes, suggests that union takes place to a molecular complex which then functions as a phosphorescence centre.

H. H. Ho.

899. *A Quantum Theory of Optical Dispersion.* **C. G. Darwin.** (Nature, 110. pp. 841–842, Dec. 23, 1922. Nat. Acad. Sci., Proc. 9. pp. 25–30, Feb., 1923.)—The author tells us that "when a theory is framed trying to explain a discrepant system of facts, it is a necessary process of thought to take some branch of the theory as more completely true than the rest, and to adjust the remaining parts in such a way that they will fit in with this base, though they may still conflict with one another." This applies to the quantum theory, based on an exact conservation of energy, the exactness of which, however, is merely one of the consequences of the very dynamical equations whose failure to explain atomic theory led to the quantum theory. Now the wave theory of light fits only with difficulty into the quantum theory, but itself forms a consistent whole. He has therefore been examining the consequences of fitting it in with those parts of the Bohr-Sommerfeld theory which seem most completely established. The result is what he believes to be a satisfactory theory of dispersion, the standard theory of which indicates a dispersion formula involving the frequency of the electron's motion in the atom which is quite different from its absorption frequency. Further, it gives great promise of future extensions in other directions, and in view of the great number of problems suggested and the probability that it will take a considerable time to deal with them, it appeared to him that it would be of interest to publish a preliminary account of a very incomplete theory.

It is assumed that the wave theory gives a correct account of events outside matter, and the terminology of electromagnetic theory is taken over, with the proviso that "electric force" is only to mean "light vector," and that how it will affect the behaviour of electrons and atoms is not prescribed. The assumption involves the exact conservation of energy in the ether; it is in interchanges with matter that it need not be conserved. When a wave passes over matter there is a mutual influence, and it is inconceivable that this should be anything but in the form of an expanding spherical wave. It proves unnecessary for the author's theory to postulate any more complicated type of such wave as emitted by the atom than the one corresponding to a spherical harmonic of zero order, in which the electric force vanishes at two poles and is elsewhere along the lines of longitude and proportional to the cosine of the latitude, while the magnetic force lies in the circles of latitude—the type given in the classical theory by a Hertzian doublet vibrating in a line. Next, borrowing from Bohr's theory, it is assumed that when an atom is struck by a wave, there is a certain probability that the atom should emit a secondary wave of this type. The scattering formula of classical theory and Lorentz's dispersion formula can then be derived, and from the linear way in which the chance of excitation depends on the incident force, it follows that the atoms act as Fourier analysers, sorting out the harmonic components of an arbitrary incident wave and refracting each in the proper degree. For selective absorption the formula obtained is practically that of the classical theory with a damping factor. Neither theory explains the mechanism of conversion of radiant energy into atomic heat. P. S. Epstein has suggested to the author that the theory will explain the defect observed in the scattering of hard gamma rays below that predicted by the classical theory. Here the wave-length of the incident light is much shorter than the distances between the electrons, and the incoherent waves cannot recombine as the classical theory would make them do. G. W. DE T.

900. *A Photoelectric Method for Investigating the Wien-Planck Law of Radiation in the Ultra-Violet.* **E. Steinke.** (Zeits. f. Physik, 11. 4 and 5. pp. 215–238, 1922. Extract of Dissertation, Stuttgart.)—The Wien-Planck law has already been investigated by a number of observers, and confirmed between $\lambda T = 50$ and 100,000, and between $\lambda = 0{\cdot}486\,\mu$ and $52\,\mu$ [Abstract 2307 (1922)]. For shorter wave-lengths the bolometer and thermopile are not sensitive enough, and the author has therefore made use of Elster and Geitel's alkali photoelectric cell as a photometer. The following results were obtained in an investigation of the cell. The sensitiveness and discharge voltage change very slowly in the course of days. There is a quick fatigue phenomenon; the current tending to a definite lower boundary value with constant illumination. This boundary value I is not proportional to the illumination; but $I^z = ML$, where M is a constant and L the illumination. The cell constant z is independent of λ and of the voltage, approaching unity for low voltages. In the experiments on the Wien-Planck law an arrangement was used in which two lamps could be employed alternately, the light of one being thrown on the cell by means of a mirror when required. The first lamp was movable on a photometer bench, and so its illumination could be adjusted to definite values; the second was run for short periods at high temperatures in order to obtain sufficient intensities in the ultra-violet. Filters were placed in the path of the light, so as to obtain as nearly as possible definite wave-lengths; the optical optima employed being 630, 535, 462, 340 and 316 $\mu\mu$. The temperature of the carbon filament of the second lamp was varied by altering the voltage, and measured from the candle-power and the input in watts by means of Lummer and Kohn's tables. Two points have been investigated; the relation between log $E\lambda$ and $1/T$, this is found to be linear for all wave-lengths; and the values of the constant c_2, which are as follows: $c_2^{(630)} = 14{,}476$, $c_2^{(535)} = 14{,}344$, $c_2^{(462)} = 14{,}302$, $c_2^{(340)} = 14{,}380$, $c_2^{(316)} = 14{,}458$. Five different temperatures were taken in each case except the last, where the special lamp employed for the extreme ultra-violet readings burnt out after three readings had been taken. Allowing for this the mean of the values for c_2 is 14,385; this agrees with the values found by Warburg and by Rubens and Michel for visible radiations. Baisch, using a photographic method, has obtained the value 14,970 for the ultra-violet. The author's observations show that the carbon of the lamp filaments used radiates as a "grey" body throughout the spectrum, including the ultra-violet region. The value of the constant C in the Wien-Planck formula was not determined. H. N. A.

901. *The Combination Principle and some New Types of Bands.* **E. Hulthén.** (Zeits. f. Physik, 11. 4 and 5. pp. 284–293, 1922.)—Bohr's frequency condition, by which the frequency of every monochromatic radiation is given as the difference of 2 terms which correspond with the energy of the light source, is generally valid and applies to molecules as well as to atoms. It is now applied by the present author to elucidate the band spectra of static and rotating molecules. It is shown that the (C + H) bands are represented by simple terms, whereby an explanation for the effect of the magnetic field upon molecules is afforded. The structure of the bands given by zinc, cadmium, and mercury has been investigated whereby regularities have been established which remain undisturbed by molecular rotation. These bands were classified into 2 types, and it appears probable that the light source of the bands is a dipole of the 3 elements mentioned with nitrogen, the spectra having been observed in air. H. H. Ho.

902. *Infra-Red Absorption Band of Hydrogen Chloride.* **W. F. Colby, C. F. Meyer, and D. W. Bronk.** (Astrophys. J. 57. pp. 7–19, Jan., 1923.)—*Fundamental Absorption Band of HCl at 3·4 μ.*—With the help of a new grating of the echelette type, which has 2800 lines to the inch and throws most of the energy into the first order in the region $3 \cdot 5\ \mu$: this band has been extended from $3 \cdot 9$ to $4 \cdot 2\ \mu$. The seven new principal lines measured bring the total number to 39 and enable the constants of the empirical formula to be determined with considerable accuracy. Revised constants for Kratzer's theoretical formula are also given, and a table of all wave-numbers, observed and calculated. A new group of faint lines was found in the new region lying between the principal lines $m = -12$ to -17, but with not quite the same spacing. The tests made prove the new lines to be real and not due to ghosts or reflections. They appear only when the gas is heated (500° C.), and they may correspond to a change of radial quantum from 1 to 2 although the frequencies do not agree with those predicted by Kratzer [see Abstract 1270 (1921)]. AUTHOR.

903. *Intensity of the Complex Lines and their Zeeman Components.* **A. Sommerfeld** and **W. Heisenberg.** (Zeits. f. Physik, 11. 3. pp. 131–154, 1922.)—The whole question of the intensity of the spectral lines is elaborately discussed in the light of the correspondence principle and its bearing on the structure of the atom is considered. J. J. S.

904. *Light Emission by Atoms through Electronic Impact.* V. *The Behaviour of Combination Lines.* **R. Seeliger.** (Zeits. f. Physik. 11. 4 and 5. pp. 197–200, 1922.)—In previous communications [see Abstract 897 (1922)] the glow methods developed gave only a qualitative comparison of the various lines produced by electrons of different velocity for a series of elements. An extension of these experiments to combination lines is now described for the mercury spectrum, which latter is very suitable for the purpose. A theoretical discussion precedes an account of the experimental details. The results show that the behaviour of the two components of the combination pair is very different. According to theory the electronic transition probability depends upon external conditions, and since in these experiments only the electrical field or the spatial ionic density come into consideration, the author opines that it may be possible by means of the correspondence principle to derive quantitative conclusions with respect to spatial distribution and the mechanism of the process. H. H. Ho.

905. *Spectra of Sparks in the Middle of a Flame.* **A. Campetti** and **A. Corsi.** (N. Cimento, 24. pp. 117–127, Oct.–Nov.–Dec., 1922.)—The occasion of this paper was an account given by H. Greinacher [see Abstract 1369 (1922)] of an investigation in which there were examined either directly or by spectrograms the spectra obtained by causing sparks from a large induction coil to pass across the flame of a Bunsen burner, using as electrodes two thick wires of platinum arranged vertically, the one above, the other below the flame. The ends of the electrodes were 3 or $3 \cdot 5$ cm. apart and placed external to the flame, in which vapours of various salts were introduced by means of a bead in the flame itself near its origin. The flame disposed horizontally was fed like an ordinary blowpipe flame. Spectrographs were obtained, and thus there were studied with alkaline metals (as well as strontium and thallium) the luminous excitation within the flame, in the limiting zone of the flame, and in the spark in the air, and besides examination was made whether the centres of emission in this last interval were to be considered as ions originating in the flame. The principal results were that whilst the band H_α of hydrogen presented *normal polarity* but only *partially*, for all the alkaline metals observed (Na, Li, K, Rb, Cs) the excited lines presented only normal polarity showing themselves thus the centres of emission in the interval of air as positive ions produced in the flame and carried by the prevailing field towards the negative pole. On the contrary, for the green band of thallium the polarity appeared inverted as if the corresponding centres of emission were negative ions. A notable result was that, although the field along the direction of the spark might be very intense, yet in it appeared specially strongly those lines which correspond to small values of the exciting potential V, which results from the quantum theory $eV = h\nu$.

The authors have examined similarly the spectra of heavy metals, seeking to find from the polarity of a given line or from its presence or absence indications with regard to the centres of emission. The spectra of salts of Zn, Cd, Hg, Ag, and also the metals of the alkaline earths Ba, Ca, Mg were investigated by the authors. It is to be observed that, whilst according to Greinacher the alkaline metals present in their principal lines normal polarity (which is confirmed in the case of sodium by the present experiments) and normal polarity is also shown by the blue band of strontium and the violet of calcium, on the contrary abnormal polarity is exhibited by the most refrangible bands of cadmium and zinc. Spectrographs in the cases of copper, manganese, and silver were not obtained giving definite results. J. J. S.

906. *Many-Lined Spectrum of Hydrogen.* **E. Gehrcke** and **E. Lau.** (Preuss. Akad. Wiss. Berlin, Ber. 32. pp. 453–458, 1922. From the Reichsanstalt.)—Photographs are given of the many-lined spectrum of hydrogen obtained with the large grating (first order) of the Reichsanstalt, using as discharge tube a glass tube 60 cm. long and 0·5 cm. diameter, silvered on the inside and filled with electrolytic hydrogen at a pressure of less than 1 mm. With this tube no trouble was experienced with the Balmer lines, which were very weak in comparison to the many-lined spectrum. Series of lines are noted with approximately constant satellite wave-length difference, the series being of the band type. Other line groups are also given, and observations on the breadths of certain lines are discussed. [See Abstracts 502 and 1244 (1909).] A. W.

907. *Absorption Spectra of Thallium and Indium Vapours.* **W. Grotrian.** (Zeits. f. Physik, 12. 3 and 4. pp. 218–231, 1922.)—By observation of the absorption spectrum it is possible to obtain information as to the quantum state of the atoms at the temperature of observation; since it is only when there is a sufficient number of atoms or molecules in a given state present that absorption lines produced by the passage of electrons from that state to a higher quantum state can be visible. The chief difference between the doublet spectra of Al, Ga, In, and Tl, the members of group III of the periodic table, the earth metals, and those of the elements of groups I and II, is that a p term, $2p_2$, is the largest of the known terms, and not an s term ($1\cdot5s$ for the alkalies and $1\cdot5S$ for the alkaline earths). It was possible that there was an unknown s term greater than $2p_2$; but the investigation of the absorption spectrum shows that this is not the case; and that, at the lowest temperature at which absorption takes place in thallium vapour, 400° C., the first lines of the subsidiary series depending on $2p_2$, $\nu = 2p_2 - ms$ and $\nu = 2p_2 - md_2$, become visible; three other lines of the first series and two others of the second appearing when the temperature is raised to 500°–600° C.; the higher lines of the two series fall in the ultra-violet, and were not observed. At 800°–850° C. the lines from the series founded on $2p_1$ begin to appear, so that the number of molecules in this quantum state is then sufficient to produce an effect on the spectrum. Other lines and bands were observed, many of which were traced to impurities, while some seem to be due to compounds. Similar results were obtained with indium, four members of series $\nu = 2p_2 - ms$, six of $\nu = 2p_1 - ms$, three of $\nu = 2p_2 - md_2$, and four doublets of $\nu = 2p_1 - mdi$, $i = 1, 2$, having been observed. The $2p_2$ series commenced to be visible at 650° to 700° C., the $2p_1$ series at about 800° C. The increase required in this case is less than for thallium, and this corresponds with the fact that the distance between $2p_1$ and $2p_2$ is less for the first metal than for the second. At high temperatures a line $\lambda = 2836{\cdot}90$ appeared, which has also been observed as an emission line; but which does not fit into the series scheme. No results could be obtained with aluminium, as it attacks the quartz tube employed. Finally it may be stated that in the case of the earth metals the electron which neutralises the positive ion seems to be held in an azimuthal two-quantum orbit. H. N. A.

908. *Visibility of Vanadium Spectrum.* **A. de Gramont.** (Comptes Rendus, 175. pp. 1129–1134, Dec. 4, 1922.)—The author has investigated the persistence of vanadium lines as the quantity of the element present is decreased, with the object of aiding analytical chemists and mineralogists. The condensed spark was employed, and observations were made both visually and photographically. Tables of results are given. A. C. M.

909. *Visibility of Alkali-Amalgam-Vapour Spectra.* **F. H. Newman.** (Phil. Mag. 45. pp. 181–189, Jan., 1923.)—In a mixture of vapours of mercury and the alkali metals, the element of lower ionisation potential should emit its spectrum to a higher degree than the others. The alkali amalgam formed the kathode of a silica vacuum tube, provided with a quartz window through which the spectrum could be observed. The tube was enclosed in an electric heater, and was excited by a 10-in. induction-coil with Wehnelt interrupter. With sodium, the sodium spectrum was brighter than the mercury above 100°, and at 200° almost entirely masked it, forming a convenient source of D-lines. At the lower temperature, the vapour pressures of both elements are small, but the sodium smaller than that of mercury, so that the ionising electrons have sufficient room to attain the energy necessary to ionise the mercury atoms, and the concentration of the latter being greater, the mercury spectrum predominates. As the vapour pressure of mercury rises rapidly with the temperature, the concentration will be much increased, and the electrons will not attain sufficient energy to ionise the mercury, although it may suffice for the sodium. With potassium this did not hold; the mercury was always brighter than the potassium, in spite of its higher ionising potential. However, the mercury lines did get fainter as the temperature increased. Lithium was similar to potassium, while rubidium and cæsium behaved like sodium. A. C. M.

910. *Ultra-Violet Absorption Spectra of Isoquinoline and Papaverine.* **P. Steiner.** (Comptes Rendus, 175. pp. 1146–1149, Dec. 4, 1922.)—The author has studied the quantitative absorption spectra of papaverine in the ultra-violet and has reached the following results: (1) The absorption curve of papaverine does not represent the curve that would be obtained by adding those of its constituents, isoquinoline and veratrol; it is an image of that of isoquinoline, but simplified and representing a more intense absorption. (2) The absorption of this alkaloid is determined by the isoquinoline group; the veratrol group plays only a secondary part. (3) The spectrum of papaverine is the same in ethereal and alcoholic solution. (4) On forming the chlorhydrate a complete fusion is obtained of the three first bands of papaverine, moreover the curve is displaced towards the red, at the same time that the absorption increases a little. (5) The absorption between $\lambda = 3261$ and 3117 Å. is characteristic of papaverine. The spectrographic method permits of the detection of 3/100 of a milligramme of papaverine in 2 $(\text{cm.})^3$ of liquid. J. J. S.

911. *The Place of the Ultimate Rays of the Elements in the Spectral Series and their Relations to the Resonance Rays.* **F. Croze.** (Comptes Rendus, 175. pp. 1143–1146, Dec. 4, 1922.)—The ultimate rays of the spectrum of an element are those which disappear last from the dissociation spectrum of a body, when the concentration of that element in the body submitted to spectral analysis is diminished. A. de Gramont has just shown that in the spectra of which the rays have been in part distributed in series, the ultimate rays are always the heads of lines of certain of these series. The author considers the relation of these rays with the resonance rays of the same elements, the first which appear when the spectrum of an element is produced by bombarding its atoms by means of electrons of kinetic energy known and progressively increasing. Gramont's table of ultimate rays coincides with that of the resonance rays for all the arc spectra in which a single system of series has been recognised. This holds for the spectra of groups I and III of the periodic classification of the elements. These spectra contain only a system of series of doublets: the ultimate rays are, like the resonance rays, the components of the first doublet of the principal ray. It appears that in all the arc spectra of group II the ultimate ray is the first ray of the principal series of simple rays. Two sub-groups have to be distinguished in group II: (1) the metals of the alkaline earths, Mg, Ca, Sr, Ba; and (2) the sub-group containing Zn, Cd, and Hg. In the first sub-group the table of ultimate rays accords perfectly with that of the rays characteristic of flame spectra, and with that of the rays characteristic of absorption spectra. The disaccord is complete with the table of resonance rays. Those rays which should be characteristic of the absorption spectrum of the vapour in the normal state are precisely lacking in that spectrum. It seems that in the first sub-group it is the first ray of the principal ray of the simple rays which plays the fundamental rôle, whilst it is not that one which is obtained most easily by kathodic bombardment. The behaviour in the second sub-group is a little different. The table of the resonance rays is in accord with that of the characteristic rays of the Bunsen flame. Considering the characteristic absorption rays it is found that the ray 1S − 1P, sharply preponderant in the spectrum of Zn in relation to the resonance ray $1S - 1p_2$, becomes less and less so on passing to the spectrum of Cd, then to that of Hg. These remarks do not constitute an objection to the theory of Bohr. Gramont's method does not prove that the resonance ray is not emitted when the spectrum shows only the first ray of the principal ray of the simple rays, it proves only that the intensity of the resonance ray has become much more feeble than that of the other, a circumstance which should be taken into account in every complete theory of spectral rays.

J. J. S.

912. *Dispersion of Prismatic Spectra in the Ultra-Violet.* **P. Salet.** (Comptes Rendus, 175. pp. 1141–1143, Dec. 4, 1922.)—The author has given a simple and rapid formula which represents with an exactitude practically perfect the observed relation between the wave-length λ and the position l of a ray in a spectrum. This formula had been verified between $\lambda 3800$ and 4900, and this note records its application to observations in the ultra-violet region, with a spectrograph of quartz with a curved plate, the dispersion being about 6 Å.U. per mm. towards $\lambda 2300$. The formula is found to represent well the position of the rays. For 25 rays between $\lambda 2250$ and 3100 the difference between the measured positions and those calculated is on the average $\pm 0{\cdot}005$ mm., *i.e.* scarcely exceeds the errors of observation. The author's method of obtaining the formula is to determine for three different wave-lengths the value $K = d\lambda/dt$. The physical fact to which he calls attention is that the following equation holds true:

$$K = A\lambda^2 + B\lambda + C$$

A, B, and C being constants. Having three values of K, the constants are obtained by the solution of three equations of the first degree, and the calculation of a table of values of K is very rapid. This table is almost all that is necessary, and rays measured will generally only have to be referred to neighbouring comparison rays. J. J. S.

913. *An Experimental Determination of the True Absorption Coefficients of Hard Röntgen Rays.* **W. Statz.** (Zeits. f. Physik, 11. 4 and 5. pp. 304–325, 1922.)—The paper commences with a critical survey of published determinations of Röntgen-ray absorption and scattering coefficients. These are found to be still contradictory and incomplete, and the author applies a recent method by Grebe and Neukirchen [Abstract 581 (1922)] for the direct experimental determination of the real absorption coefficients. This method employs spherical absorbers and has been carried out for aluminium and water, using 5 practically homogeneous filtered radiations with a wave-length range of $\lambda = 0{\cdot}1$ to $0{\cdot}5 \times 10^{-8}$. Tables of data are included in the paper. The values of the absorption coefficients are in a logarithmic series which for long waves show the dependence of the real absorption coefficients on wave-length, and ratify the existing results for short waves. The scattering coefficients for aluminium form a remarkable series for the wave-length range (0·13, 0·16, 0·15, 0·16, 0·26). Diagrams are included which show the intensity relationships of a scattering medium in dependence upon the hardness of the rays. By utilising Neukirchen's measurements with γ rays in the above diagrams, it follows that the deviating behaviour of the γ rays may perhaps be within a region of selective absorption below $\lambda = 0 \cdot 1 \times 10^{-8}$. H. H. Ho.

914. *Röntgen Radiation from the Kathode in Autoelectronic Discharge.* **J. E. Lilienfeld.** (Phys. Zeits. 23. pp. 506–510; Disc., 510–511, Nov. 15–Dec. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—The author has previously described experiments in which, with a knife-edged or pointed kathode and small distance (1 mm. to 6 mm.) between kathode and anode, it was possible to get a discharge in a high vacuum with a moderate voltage, without any heating or luminous effect at the kathode, or in the space between the anode and the kathode. When the stream or streams of electrons strike the anode a blue-grey radiation is given off. The voltage required depends on the metal of the kathode; being small for metals which show the photoelectric effect with large wave-lengths. A pointed caesium electrode, 1 mm. from the anode, required only a few hundred volts, while heavy metals, under the same conditions, require over 5000 volts. Even blunt kathodes are effective if the voltage is high enough. The autoelectronic discharge is practically independent of the temperature, though liquid air has an indirect effect by improving the vacuum, and so slightly increasing the discharge. It is found that the kathode gives off X-rays which are softer than those given off by the antikathode, and so cannot originate from the latter by scattering from the kathode surface. A photograph taken with a pin-hole camera shows that they are only given off from the point or points of the kathode; and it seems probable that the electrons also come from the points; in other words, they originate in regions where the field intensity is high. To produce X-rays of such high frequency as to pass not only through the glass walls of the tube, but through about 1 mm. of aluminium, the actual "jump" in potential would have to take place within one atomic diameter, so that the radius of curvature of the point must be very minute indeed if this explanation is adopted. The author considers that some interatomic phenomenon may be concerned; but points out the difficulties involved in this conception. He also considers the possible behaviour of the "cloud" of electrons, which may be thought of as surrounding the metal surfaces. In the *discussion*, **W. Schottky** suggested that the phenomenon was due to submicroscopic points, which suggestion he had made in connection with Rother's experiments on electric discharge with short distances and low voltages [Abstract 741 (1923)]. H. N. A.

915. *New Experimental Aids for Röntgen Spectroscopy.* **H. Stintzing.** (Phys. Zeits. 23. pp. 463–473; Disc., 473–474, Nov. 15 and Dec. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—The limited application of Röntgen spectroscopy in practice is in striking contrast to the increasing importance of spectroscopy in chemistry and physics, a circumstance due in part to the peculiar nature of the apparatus in vogue. The present contribution seeks to provide improved facilities in this direction. The vacuum technique involved is first considered at length, and a new design of steel mercury pump described, although a separate communication [see Abstract 803 (1923)] should be consulted for complete details. This pump permits larger apparatus to be constructed than hitherto in use. The following section is devoted to the high vacuum spectrograph in use for the study of the ultra-violet and Röntgen rays. This is described in detail with numerous diagrams and with a summary of its possible applications, together with a brief reference to methods employed by different investigators. The final section considers a space lattice model for calcspar and a space conception of the periodic system for chemical elements. An appended discussion serves to render prominent and to elucidate any ambiguities in the text of the paper. H. H. Ho.

916. *Continuous X-Ray Spectrum.* **E. Wagner** and **H. Kulenkampff.** (Phys. Zeits. 23. pp. 503–506, Nov. 15 and Dec. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—Recent investigations on the continuous X-ray spectrum [see Abstract 689 (1923)] have dealt mainly with the Duane-Hunt law of limiting frequency. Measurements of the limiting frequency and the minimum exciting voltage at this frequency have given very accurate values of Planck's fundamental constant h. The authors now describe an investigation of the intensity distribution in the continuous spectrum, and its variation with the atomic number of the antikathode-element and with the voltage of the kathode-rays. The 100 planes of calc.-spar and rock-salt were used to reflect the X-ray in the experiments. A simple relation is discovered which gives the atomic number of the element from the experimental results. A. B. W.

917. *Corpuscular Spectra and Photoelectric Effect.* **Maurice** and **L. de Broglie.** (Comptes Rendus, 175. pp. 1139–1141, Dec. 4, 1922.)—In the magnetic corpuscular spectra of the electrons emitted by the elements under excitation by X-rays, the energy of a corpuscular ray due to electrons ejected at a level K is of the form $h(\nu - \nu_K)$, where ν is the frequency of the exciting radiation, and ν_K that of the critical discontinuity K. Whiddington recently remarked that he has not observed the corpuscular rays of the type mentioned, when $h(\nu - \nu_K)$ is less than $h\nu_K$ [Abstract 2289 (1922)]. The authors have examined this point and find on examining the spectra of various elements that the results show that the corpuscular rays emanating from a certain level grow feebler, but do not disappear when their remaining energy becomes inferior to that of this level. It is found that the total energy of the group of corpuscles composing the ray (the product of the number of corpuscles by the energy of each) is expressed by $I = A\nu_{K^2}(\nu - \nu_K)/\nu^4$. This may be regarded as a function of the atomic number N, on replacing ν_K by its value as a function of N. This expression, when the atomic number rises, passes through a maximum and then decreases rapidly; this is confirmed by experiment, but the position of the maximum is difficult to verify. It is impossible at present to answer completely the question: What becomes of the electrons liberated in the interior of a solid by penetrating exciting rays? Some go out with energies revealed by the rays of the corpuscular spectrum. A great part of the energy of others is finally converted into heat. If it is supposed that the losses of velocity are produced only by shocks bringing into play the quanta, there will result in ordinary conditions a lowering of the individual energy of the corpuscles till it becomes inferior to that which corresponds to the first potential of ionisation. The shocks are then elastic and the conversion into thermal energy takes place. Brillouin has developed a theory of the continuous background of the X-rays which introduces also the notion of thermal agitation at the end of the course of the electrons. Towards the end of their career a large number of electrons have their energy grouped around a value of some volts, and the numerous slow electrons noticed by Shearer may be thus accounted for. These facts are supported by the observations of Ledrus, and Millikan's experiments seems also in accordance therewith. J. J. S.

RADIO-ACTIVITY.

918. *Recent Practice in the Testing of Radio-Active Preparations.* **W. Bothe.** (Zeits. Elektrochem. 28. pp. 459–460, Nov. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—The paper outlines methods recently developed at the Physikalisch-Technischer Reichsanstalt for the determination of quantities of radio-active materials, whether enclosed in vessels or exposed. The methods refer essentially to strongly active preparations (10 to 100 m.g. of radium). A. B. W.

919. *Radio-Active Spring at Échaillon, France.* **J. Cluzet** and **A. Chevallier.** (Comptes Rendus, 175. pp. 1163–1165, Dec. 4, 1922.) —The mineral spring at Échaillon, Maurienne, is of the sodium chloride type. The sediments from the spring show amounts of radio-activity that vary, owing to variation in amounts of iron salts which accompany the radio-active material. These sediments contain radiothorium, and this is the only case in France where a natural source of radiothorium is available for therapeutic purposes. The gases from the spring had to be sent away for examination, and owing to the time interval the thorium emanation was not detected in them. W. A. R.

920. *Passage of α- and β-Particles through Gases.* **D. Bose.** (Zeits. f. Physik, 12. 3 and 4. pp. 207–217, 1922. Extract of Dissertation, Berlin.)—The trajectories of the particles were studied by means of a modified Wilson expansion apparatus, constructed entirely of glass; and provided with a large valve worked by an electromagnet, which made sudden expansion of the air in the working chamber possible. Interesting photographs were obtained, showing the paths of H-particles set in motion by collision of α-particles, the number of these agreeing well with the probable number obtained from the formulæ of Rutherford and Darwin. No H-trajectories were observed when the α-rays passed through methane. Several anomalous deviations of the α-particles were photographed, some of which may be due to collisions with heavier atoms, such as oxygen. A mica plate was fastened with sealing-wax to a copper plate, and placed so that the α-rays struck it obliquely. If the copper plate and the inside of the glass chamber are connected to the poles of a battery the trajectories of the α-particles are seen to bend suddenly on reaching the mica surface, running along the surface for some distance in a diffuse track. This bending is not seen when the copper plate is not connected to the battery. The author thinks that the α-particle is deflected into the layer of adsorbed gas (hydrogen or air) on the surface of the mica in both cases, and that when the copper backing is charged the ions produced by collisions are driven out from this layer for a short distance, so that water can

deposit on them. Photographs were also taken of the paths of β-rays, and some of them were observed to branch, indicating collision between the β-ray electron and another electron, giving a secondary β-ray.
H. N. A.

921. *Theory of Scattering of β-Rays.* **G. Wentzel.** (Ann. d. Physik, 69. 5. pp. 335–368, Dec. 12, 1922.)—Measurements of the scattering of β-rays have so far shown very imperfect agreement with the Rutherford atomic theory. The experiments of Crowther seem to be in favour of J. J. Thomson's theory, while the later experiments of Crowther and Schonland show a scattering which is sensibly larger than Rutherford's theory requires, unless Coulomb's law ceases to be correct near the nucleus, or the electrons are also magnetons and are affected magnetically by the nucleus; the author does not consider either of these alternatives probable, and endeavours to reconcile the theory quantitatively with the measurements. Darwin and Bohr have considered the transfer of impulse to the atomic nucleus and atomic electrons; and Darwin the variability of the mass and loss by radiation; but none of these corrections bring the theoretical curve appreciably nearer the experimental. The combined effect of the atomic electrons has not been taken sufficiently into consideration. Rutherford has dealt with this screening action, in the case of α-rays, by assuming that the negative electricity fills a sphere of about 10^{-8} cm. radius uniformly. The conclusion he draws for α-rays does not apply to β-rays, on account of their smaller kinetic energy. In any case the screening action of the electrons will cause a *diminution* of the scattering, and so increase the discrepancy between theory and experiment. The author's solution of the difficulty is that the scattering is due to multiple impacts of the β-ray electron on the atoms of the scattering material, and he works out a detailed theory on this basis; loss of velocity, absorption of the particles, radiation inelastic impact, and any direct alteration of path caused by atomic electrons are neglected; and the atomic structure is taken as greatly simplified. The Bohr electron shell with the largest number of electrons is picked out, and the electricity of all the electrons of the atom is supposed to be spread out over the surface of this sphere (radius R). The atom model now consists of the nucleus, with charge Ze, and the above sphere with charge − Ze. Particles outside the sphere pass by without any deviation; those that enter it follow hyperbolic paths and are deviated. A comparison of the results of the theory with Crowther's results for different thicknesses of gold leaf shows good agreement, while the theory of single scattering proves to be quite unsatisfactory. The results of the new theory are not so good when applied to aluminium, copper, and silver, but are fairly satisfactory qualitatively.
H. N. A.

922. *The Orbits of β-Rays.* **W. Bothe.** (Zeits. f. Physik, 12. 3 and 4. pp. 117–127, 1922. From the Reichsanstalt.)—Hitherto statistical researches on β-ray orbits according to the Wilson fog method have not been carried out to the same extent as for α-ray orbits which have been investigated under a wide range of conditions. By this method, however, the β-ray orbits are recognised as a series of very fine drops of mist, the density of which increases as the rays are slower. On account of the extraordinary delicate structure of this fog, the number of well-defined orbits is very small when using the mercury spark illumination of Wilson. The conditions have now been overhauled and found to be much more favourable when a continuous light source of sufficient intensity is employed. A number of orbits have been photographed and the experimental conditions are very fully described. Ramifications have been observed which are traced to the abnormal impacts of β-particles with atomic electrons whereby secondary β-rays are produced at the expense of the energy of the primary β-particles. Sharp bends were also observed for the more rapid β-rays. The curvature course of a ray thus corresponds to its formation from a series of independent deviations. A mathematical discussion is included in the paper. H. H. Ho.

923. *Distribution of Intensity due to γ-Rays in Absorbing Media.* **W. Friedrich** and **O. Glasser.** (Zeits. f. Physik, 11. 2. pp. 93–106, 1922.)—The problem is one of great importance in medical practice, and has also considerable physical interest. Radium is generally employed in small tubes, and these can be introduced into the tissues in different positions and in different combinations, the intensity at any point depending on the absorption of the medium and on scattering. A very minute ionisation chamber was employed, the volume being only 0·5 cm.^{3}. This was placed in the middle of a large trough of water, and the radium tube was placed in different relative positions at different distances from it. In this way the surfaces of equal radio-active intensity round the tube were determined, and the effect on their shape of using several tubes end to end or side by side was investigated. It was found that absorpiion taking place in the radio-active substance itself has a very considerable influence on the shape of the surfaces, the intensity being much less at the ends of the tubes than at the sides. This effect is exaggerated by placing several tubes end to end. By arranging two or three tubes at right angles to a plane through their middle points, at suitable distances apart, surfaces of equal intensity which approximate to spheres can be obtained; such arrangements appear very suitable for medical purposes. H. N. A.

924. *Distribution of the Intensity of γ-Rays of Radio-Active Substances in an Absorbing Medium.* **R. M. Sievert.** (Zeits. f. Physik, 12. 3 and 4. pp. 243–244, 1922.)—This is a criticism of a paper by W. Friedrich and O. Glasser [see preceding Abstract]. Their formula $D = It\mu$ is only correct for a perfectly homogeneous radiation. D, the "dose," is the product of the actual radio-active intensity and the time, I is the radio-active intensity at the point if the absorbing medium is removed, t the time, and μ the coefficient of absorption. With a radium preparation, shielded in turn by 0, 1, 2, and 5 mm. of lead, the percentage amount of K_1, K_2, and K_3 γ-rays varies very greatly, as shown in a table. The differences are such as to lead to variations of over 15 % in the "dose," in the particular case considered. The author is also of opinion that these authors have extrapolated too far on the curves in determining the intensity at short distances from the ends of the radium tubes. H. N. A.

HEAT.

925. *Thermal Properties of Aluminium-Silicon Alloys.* **J. D. Edwards.** (Chem. and Met. Eng. 28. pp. 165–169, Jan. 24, 1923.)—An abridged account is given of the history of and experimental methods employed in the determination of the thermal volume changes and densities of aluminium, and its alloys. A curve of density-silicon content at 20° C. is given, whilst tabular results are also included; in comparison with Frilley's results the data on 10 and 20 per cent. silicon alloys is about 5 per cent. higher.

The density of solid aluminium-silicon alloys at temperatures of 200° C. and 563° C. was determined, data being thus obtained to determine the expansivity. The densities of liquid aluminium-silicon alloys were determined with a graphite densimeter, in relation to pure aluminium; tabular and graphical results of the measurements are given. The existing data on the expansivity of aluminium and silicon are discussed, and the estimated value for the eutectic alloy (11·63 per cent. silicon) from the density measurements at 20° and 200° C. is given as $22{\cdot}2 \times 10^{-6}$, which is about 10 per cent. less than that of pure aluminium. Between 20° and 577° C., the mean expansion coefficient as determined by measurements of total shrinkage is about $23{\cdot}5 \times 10^{-6}$, while that of aluminium over the same range is about 29×10^{-6}. The solid and crystallisation shrinkage of aluminium-silicon alloys was also determined, in reference to the casting qualities of the alloy, curves and tabular results being given. The total shrinkage per foot, from 577° to 20° C., was found to vary from 0·15 to 0·21 inch for the alloys tested. Comparisons of various properties of aluminium-silicon and aluminium-copper alloys are also made in this paper, with special reference to their casting qualities, the percentages of silicon and copper in these alloys being 11·6 and 8·0 respectively [see also Abstracts 84B (1923), 1331 and 1332 (1921)]. A. W. J.

926. *Construction of Vacuum Bolometers.* **C. G. Abbot, F. E. Fowle,** and **L. B. Aldrich.** (Smithsonian Inst. Astrophys. Obs. Annals, 4. pp. 45–64, 1922.)—The theory of both vacuum and air bolometers is treated and a number of cases are worked out for various dimensions and materials of the bolometer strip. Under the conditions met with in solar spectral work, a thick strip seems the most sensitive. Practice confirms this, but the sluggishness is a great objection and lighter elements are finally adopted. For stellar spectral investigations light thin elements have the advantage. Generally vacuum bolometers are about ten times as sensitive as similar instruments in air, while the material of the strip is not very important. A. Wh.

927. *The Chemical Constants of the Halogens in the Mono- and Di-Atomic States.* **F. A. Henglein.** (Zeits. f. Physik, 12. 5. pp. 245–252, 1922.)—For monatomic gases Stern and Tetrode give the expression $C = -1{\cdot}60 + 1{\cdot}5 \log M$ for the chemical constant, where M is the molecular weight of the gas, a formula verified experimentally by

Nernst. For polyatomic gases the chemical constant can be determined from the vapour pressure formula when the temperature course of the molecular heat is known. According to Langen the amount of the decline of rotation energy can be referred to the chemical constant for a temperature range where the gas exhibits its normal state, and by means of this constant equilibria can be calculated for polyatomic gases. In this connection the halogens are of especial interest and form the subject matter of the present paper. Section 1 deals with the specific heats and thermal contents of the halogens in the solid state. Section 2 considers the chemical constants in the monatomic condition, and Section 3 in the diatomic state. These are calculated from the dissociation and evaporation equilibrium, and increase with the temperature and according to the log of the atomic or molecular weight respectively. Of all substances investigated, *viz.* I_2, Br_2, NO, O_2, Cl_2, N_2, CO_2, NH_3, H_2, and iodine and bromine have the highest chemical constants, the order of decrease being that above. A Debye function is given for calculating the specific heat of solid bromine. H. H. Ho.

928. *The Absolute Pyrheliometric Scale.* **W. Marten.** (Meteorolog. Zeits. 39. pp. 342–344, Nov., 1922.)—The first useful process for the measurement of the absolute value of radiation without involving a large error was proposed by Kurlbaum and Ångström, separately and independently, and depends on the principle of electrical compensation. Measuring strips are employed under identical conditions determined by a thermoelectric null method. The theoretical weakness of the method lies in the employment of incomplete black materials, and this problem has been investigated by Coblentz and Emerson [see Abstract 699 (1916)]. Also error can arise through the different kinds of heating to which the measuring strips are subjected, *viz.* by radiation from without and by the electric current from within. A third systematic error arises in that the compensation current flows through the entire length of the strip, while heating by radiation requires the strip edges to be in the shade to prevent its attachments being affected. The present paper deals with the quantitative estimation of error in Ångström's method, for which the compensation pyrheliometer No. 140III of the Met. Observatory at Potsdam was employed. This instrument together with the experimental details are described at length, and tables of data included. The following conclusions are drawn: (1) The magnitude of the edge-effect grows with increased shading. (2) The readings of Ångström's compensation pyrheliometer are 2·8 % in error through the edge-effect. (3) The measurements only exhibit the tendency of slight increase through the edge-effect with increasing intensity, although this result is not to be deduced with certainty, and requires conduction and convection effects to be taken into account. Ångström has derived the edge-effect theoretically and found 1·3 % as the correction, but the present author gives 2·8 % as the more accurate value. The paper concludes with a comparison of the Abbot and Ångström instruments, in which the latter is greatly to be preferred. H. H. Ho.

929. *Some Noteworthy Properties of Gases.* **F. Wächter.** (Zeits. techn. Physik, 4. 2. pp. 56–63, 1923.)—In an earlier paper, the author has pointed out three remarkable properties of gases which seem to have hitherto escaped attention, *viz.*: (1) There is a maximum velocity possible for the movement of a body in a gaseous atmosphere. (2) When a body possesses a speed near to this critical velocity the gaseous molecules of the medium can yield no further to the pressure exerted by the moving body. The gas molecules are therefore pressed together within the region of molecular attraction and so pass into the solid state, whence they can then emit transverse light oscillations. (3) For a gravitational field of given intensity, each individual gas possesses a special limiting temperature above which the gas is apparently imponderable. The present paper is devoted to an examination of the means by which these phenomena can be experimentally established. For the first property, experiments with explosives and observations on meteors are described. For the second phenomenon, photographs of suitably installed explosions are taken by which three flame characteristics are noticed, from which is deduced the fact that the air compressed by the explosions has been caused to emit a bright glow. The latter when spectroscopically examined, exhibits a very intense continuous spectrum. This spectrum while in part due to solid dust from the explosive is also held to be an effect of the compressed air behaving as a solid under the intense compression. Effects of various violent explosions are adduced in support of this contention. A short theoretical discussion of the third property is given. In an appendix, the author replies to some conclusions by Wolff on the propagation of explosive waves in air. H. H. Ho.

930. *Test of van der Waals' Equation of State, as Corrected for Apparent Diminution of the Molecular Dimensions.* **E. A. Holm.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 17. No. 1. pp. 1–101, 1922.)—The form of the corrected equation tested is $pv = \mathrm{RT}/[1 - b/v + 3b^2/8v^2 - 0\cdot0369b^3/v^3] - a/v^2$; this is an approximation to the theoretical value deduced from the kinetic gas theory; terms in b^4/v^4 and higher powers of b/v being neglected. The author fits this equation to the observations of Amagat on O, N, and H; and finds it possible to do so, in the case of O for example, for the isothermal 0° C. from 100 to 250 atmospheres pressure, for 16° C. from 150 to 300, for 100° C. from 150 to 300, and for 200° C. from 200 to 450 atmospheres, with errors of the same order as the probable observational errors, distributed unsystematically about the curve. For higher pressures the errors, δ, are consistently positive, and increase with the pressure; being equal to 16·6 % at 0° C. and 1000 atmospheres. Nitrogen behaves in a very similar way; while with hydrogen the percentage error at high pressures is smaller. This systematic deviation of the calculated from the observed values is not due to the neglect of terms in b^4/v^4 and higher powers of b/v; and, since the equation tested depends on the kinetic theory of gases, the conclusion is that the theory is in some way incorrect. The same result follows from a consideration of the relation between the equation and the values obtained by Mathias and Kamerlingh Onnes for the critical temperature, pressure, and volume of oxygen; and by the same authors and Crommelin for these quantities with N and H. It is shown that the error δ of the equation of state at the critical point is in each case negative; being − 20·9 for O, − 21·0 for N, and − 15·5 for H. This confirms the view that the theory is faulty. H. N. A.

931. *Saturated Fluids near the Critical Point.* **E. Ariès.** (J. de Physique et le Radium, 3. pp. 411–421, Nov., 1922.)—The author makes a very full examination, graphically and analytically, of two forms of the saturation curve ACB shown in Figs. 1 and 2 as pv and TS curves, respectively. In both, p is the pressure, u, s, $m = T\dot{s}$ and u', s', $m' = T\dot{s}'$ are the specific volume, entropy, and specific heat of the saturated liquid and vapour, respectively, and $L = T(s' - s)$ is the heat of vaporisation. Then p and s are definite functions of v and T, except at points on the saturation curve, where they are functions of T only. Clapeyron's theorem $\partial P/\partial T = (s' - s)/(u' - u) = \Delta s/\Delta u = L/T(u' - u)$ is assumed, together with two hypotheses, the validity of which the author considers adequately established by experiment: (1) Immediately adjoining the critical point C, $(\partial P/\partial T)_c = a$, a positive quantity which can never be zero or infinite; (2) the saturation curve has first order contact with its tangent at the critical point. It follows that $L_c = O$, and that the saturation curve can have no singularity at C. Also for $T = T_c$, $m = +\infty$, $m' = -\infty$, $m'/m = -1$. Hence it follows easily that $\dot{L} = -\infty$, $(m' - m)/\dot{L} = (\dot{m}' - \dot{m})/\ddot{L} = 1$. Three formulæ giving finite values of simple functions of L, $\dot{L}$, and $\ddot{L}$ are obtained from the consideration that m, $\dot{m}'$, L, $\dot{u}$ and $\dot{u}'$, which are infinite at the critical point, can be taken in pairs of the same order. An empirical expression $L = (T_c - T)\{a \log (T_c - T) + \beta\} + \gamma(T_c - T)^{1/2}$, is proposed by the author, which satisfies all these critical point conditions, provided γ is a positive quantity, and these exercise a dominant influence on the value of L for some distance on each side of the critical point, moreover, it makes L imaginary for any temperature above the critical point, which is logical. The constants a, β, γ, are found from three linear equations by applying the empirical formula to three observed values of L at different temperatures. If these are equally spaced, starting from the critical point the calculation will be simplest, but the formula holds good only when the value so obtained for γ is positive.

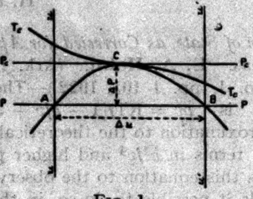


FIG. 1.

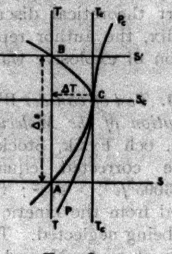


FIG. 2.

G. W. DE T.

932. *Absolute Entropy and Chemical Constants.* **K. F. Herzfeld.** (Ann. d. Physik, 69. 1. pp. 54–58, Oct. 19, 1922.)—This is a short note on the deduction of the entropy constants which the author contributes to a discussion on the subject [see P. Ehrenfest and V. Trkal, Abstract 1576 (1921)] with the hope of removing some obscure points, by employing a method previously used (Herzfeld, Zeits. phys. Chem. 95. S. 139, 1920). It is concluded that by employing Planck's "Zustandsintegral" the absolute value of the entropy can be calculated on the classical theory for high temperatures, and that the introduction of the quantum theory is only necessary at low temperatures. T. B.

933. *Mass-Effect in Entropy.* **E. D. Eastman.** (Am. Chem. Soc. J. 45. pp. 80–83, Jan., 1923.)—The hypothesis that the expression for the mass-effect in the entropy of all substances in which equipartition holds takes the same form as for monatomic gases is tested for all cases for which data are available. Much evidence is found supporting the hypothesis, and none definitely contradicting it. Several approximate equations are given for the calculation of the entropy of diatomic gases and of metals. A. D.

934. *The Quantum Theory of Gases and Liquids.* **A. Byk.** (Ann. d. Physik, 69. 3. pp. 161–201, Nov. 16, 1922.)—Some time ago [see Abstract 950 (1922)] the author introduced a method for bringing the quantum theory into the theory of gases and liquids. In this method Planck's energy quantum is combined with the theory of corresponding states. This theory, extended to the free energy of corresponding states, is referred to as the quantum theory of corresponding states. The present paper is an extension of the former one, and the author attempts to deal with all the phenomena comprised under the theory of corresponding states. The equations of state of K. Onnes and Keesom, Kirstine Meyer, Avogadro, Berthelot, and Wohl are discussed, and tables of constants for a large number of substances are given. Imperfect gases are then considered. The inversion temperature of the Joule-Kelvin effect, entropy, Nernst's chemical constant, and specific heat, are dealt with. Trouton's rule for latent heat is discussed, and finally viscosity, capillarity, and molecular refraction are touched on. T. B.

935. *The Partition Law of Molecular Velocities and Surface Actions.* **C. E. Guye.** (Soc. Phys. Hist. Nat. 39. pp. 132–134 and 153–155, Aug.–Dec., 1922. Suppt. to Arch. des Sciences, Nov.–Dec., 1922.)—The author shows that, in the case of a perfectly elastic containing vessel, the effects of the surface impacts are preponderant; but when the walls of the containing vessel are only partially elastic, the volume effects predominate. In both cases, the dissociation velocities approximately obey van't Hoff's law when the molecular velocities are of the experimental order. This law is consequently confirmed by purely kinetic considerations. G. W. DE T.

936. *Thermodynamics of Crystal Lattices.* II. **M. Born** and **E. Brody.** (Zeits. f. Physik, 11. 6. pp. 327–352, 1922.)—From the first paper [Abstract 1077 (1922)] it had appeared that according to the lattice theory the coefficient of expansion should, at low temperatures—for higher temperatures a proportionality between atomic heat and expansion coefficient is not to be expected—be proportional, not to T^3 (Grüneisen), but to T, and this latter view was supported by the pyroelectric measurements of W. Ackermann (1915) and the arguments of S. Boguslawski (1914). On further investigation Born finds an error in the method of approximation he had applied. Correcting this error, the authors confirm Grüneisen, so that Ackermann's experiments would have to be repeated. The mathematical paper chiefly deals with the calculations of diatomic regular crystals of the rock-salt type (halogen compounds of Na and K) and in particular with the question, whether the assumption of electrostatic forces of cohesion suffices for the explanation of the expansion phenomena, as well as for the calculation of the elastic properties and infra-red frequencies. Minor mistakes are discovered in some of the previous calculations. Methods of approximation have again to be applied. Cohesion seems to be due to electrostatic attractions between the ions; there are further forces proportional to r^{-n}, r being the distance between two neighbouring ions. The values of n (lying between 7 and 10) are deduced from density and compressibility data. A comparison of the calculated and observed elastic constants suggests that the r^{-n} force should be repulsive between ions of different kinds, and attractive between ions of the same kind; reduced to the same distance, the latter force would be about half as strong as the former. Ions of the same kind must repel one another when nearest neighbours, since otherwise the lattice would collapse. In direction these structural r^{-n} forces are opposed to the r^{-1} Coulomb forces. The mutual attraction of ions of the same kind may be accounted for by assuming that their electrons do not merely describe the same paths, but are also in the same phase. The constant γ of Mie and Grüneisen, which roughly determines the ratio between expansion coefficient and atomic heat, has two limit values, for low and for high temperatures. The infra-red vibrations must hence not be considered to be monochromatic. H. B.

937. *Outline of a Theory for the Anisotropic Radiation Field.* **G. Jaffé.** (Ann. d. Physik, 68. 7 and 8. pp. 583–632, Oct. 4, 1922.)—If bodies at different temperatures are immersed in a material medium under such circumstances that thermal conduction can be neglected in comparison with thermal radiation, the radiation field which arises is of necessity anisotropic. This is valid for stationary as well as for variable processes, since no energy translations from the warmer to the cooler bodies or between different parts of the field are able to occur if everywhere the radiation intensity is the same in all directions. The medium is characterised by the velocity of propagation and the absorption coefficients of the thermal rays, both as functions of temperature and of oscillation frequency, and the state of radiation is fully described when the intensity of radiation is known for every direction at any point of the field. For solving the problem of finding the radiation state, when the velocity of propagation and absorption coefficient are given as functions of position with given boundary conditions, two processes are applicable, *viz.* one involving the linear inhomogeneous integral equation derived by Hilbert as a basis for radiation kinetics; and the other a generalisation of the method employed by Eddington for his theory of stellar radiation equilibrium. The processes are distinguished essentially by the choice of fundamental units, *viz.* Hilbert's method determines the emission coefficients as a function of place and derives the radiation intensity as a function of direction involving an integration process, while the Eddington method makes the radiation intensity the principal unknown and then determines the emission coefficients. By each process the solution is obtained in the form of a series, and by the Hilbert method with limitation to the stationary case. It is found that both processes can be completed and the physical state determined whether the absorption be strong or weak.

The Eddington method affords a very simple solution for the limiting case of very strong absorption, while on the other hand the Hilbert integral equation is more convenient for weak absorption. The first section of the paper is devoted to the fundamental equations of the problem. Two of the latter are designated the equations of continuity and motion of the radiation, the first giving the energy expression for every volume element, and the second the manner in which radiation in a definite direction changes its intensity by absorption and new emission. For the treatment of these equations the radiation intensity is stated in the form of a series which is expanded in general spherical functions. The first coefficients of this series have a simple physical interpretation, *viz.* the coefficient of zero order relates to the radiation density, while the 3 coefficients of the first order are proportional to the components of a vector which is analogous to the thermal current in the theory of thermal conduction and is styled the radiation current. By introducing this vector the equation of continuity is greatly simplified, while from the equation of motion are derived partial differential equations for the coefficients of the spherical function series. Section 2 treats the stationary problem; whence it appears that in the generalisation of the valid hypothesis for isotropic radiation the emission coefficient is proportional to the radiation density. Limitation to the special case of strong absorption has evoked the result that the radiation current is proportional to the decline of radiation density, and the relations appear completely analogous to those of thermal conduction. The next approximation, considering the higher terms, has only been worked out for the linear case, and the latter only has been examined for weak absorption *via* the solution of the Hilbert equation. Section 3 deals with non-stationary processes for the limiting case of strong absorption, and here a strong analogy to the corresponding thermal problem is found, *i.e.* the Fourier method is applicable. Finally, Section 4 gives a comparative treatment of thermal conduction and thermal radiation for the above special cases. The paper is mathematical throughout.

H. H. Ho.

938. *An Addition to the Theory of the Anisotropic Radiation Field.* **G. Jaffé.** (Phys. Zeits. 23. pp. 500–503, Nov. 15 and Dec. 1, 1922. Paper read before Deut. Physikertag., Leipzig, Sept., 1922.)—This paper is supplementary to a recent communication by the author on the same subject [see preceding Abstract] in which the assumption was made that the medium was spatially homogeneous apart from a dispersion and scattering of the radiation. In the present investigation the fundamental equations are derived for the case of a non-homogeneous and dispersive medium. Two assumptions are made for this purpose: (1) In the medium no transformation may occur from energy of one oscillation frequency into that of another. (2) If the process is not stationary, the change of the specific heat content of the medium is neglected in comparison with the alteration in the radiation density. The general equations deduced are found to be converted into those previously derived when the medium is homogeneous. The paper is entirely mathematical.

H. H. Ho.

SOUND.

939. *An Apparatus for Transferring Sound from Water to Air and in the Reverse Direction.* **W. Hahnemann, H. Hecht,** and **H. Lichte.** (Zeits. techn. Physik, 4. 3. pp. 93–99, 1923.)—In the most favourable case, when the sound falls perpendicularly on the dividing surface, only 1/1000 of the energy can be transferred from water to air, or from air to water. The authors were given the problem of the construction of a receiver, without any electrical contrivance, such as a microphone or telephone, which would enable sounds transmitted through water to be heard, and have succeeded to a certain extent in its solution. In the first instance they make use of ideas derived from wireless telegraphy, and think of a tuned " sound antenna," which is able to take up energy out of " the sound field " from larger cross-sections than its own surface. A simple form of such a receiver consists of a metal tube, a few centimeters in diameter, closed at one end by a membrane, which is placed in the water, while the other end is brought to the ear of the observer. The membrane is tuned to the sound to be received, and is placed several wave-lengths below the water surface. This simple arrangement, however, is not very satisfactory, on account of the great difference between the elastic properties of air and water, and the relations between its parts are similar to those in an electric cell or dynamo with very large internal resistance and an external circuit with very small resistance. Suppose now that a piston is introduced into the tube, and is brought nearer and nearer to the membrane, so as gradually to diminish the volume of the air acted on by it, the pressure of the air being kept constant; it will be found that the tuning of the membrane will be affected, becoming higher, and the enclosed air space will contribute an appreciable part to the elasticity of the sound antenna. Thus an appreciable part of the vibrational energy will exist in the air space, and some of this can be given to the ear by making a small hole in the piston, connecting it to a conducting tube, and arranging the dimensions so that the elastic or wattless action of the closed air space is diminished and converted into a watt-current in the tube. The receiver is also discussed from the purely acoustical point of view, the air space being regarded as a Helmholtz resonator coupled to the membrane; and the effect of tuning the resonator to the membrane is fully considered. It is estimated that the efficiency of the combination may reach 20 %. H. N. A.

940. *A Watertight Apparatus for Detecting the Sound of Aircraft.* **E. Lübcke.** (Zeits. techn. Physik, 4. 3. pp. 99–101, 1923.)—The apparatus was intended for use in submarines, and was to be attached to the top of the periscope. This introduced a number of limitations as to size and construction. A carefully designed watertight microphone arrangement was not satisfactory; but a watertight Bell telephone was constructed, which gave an audibility radius about equal to that of the unaided ear, and which, while it modified the sound to some extent, reproduced it in a characteristic and recognisable manner. H. N. A.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

941. *Electrodynamics and the Principle of Reaction.* **H. Arata** and **M. Brun.** (Rev. Gén. d'Él. 13. pp. 203–207, Feb. 10, 1923.)—When the forces to which two elements of current are subjected are calculated by the application of the laws of Laplace it can be proved that the resultant force is not generally zero, so that such a system, supposed realisable and rigid, would set itself in motion on its own account. It is usual to explain this consequence of the laws of Laplace by saying that it is not valid to argue about the actions on elements, and that for closed circuits Newton's principle of the equality of action and reaction is necessarily respected. The authors show that it is absolutely legitimate to reason about the elements of a current, of which an electric charge in movement, such as an electron, is a practical example. The first law of Laplace, which leads directly to Rowland's expression for the magnetic field strength due to a moving charge, must be given a physical reality, and permits the authors to establish a general principle leading to the conclusion of equality between action and reaction. In most practical examples it is not possible to take account in calculation of the reaction, since the forces on the elements nearly always have a zero resultant. When this is not so the calculations are generally manifestly incorrect, or the reaction shown to exist explains naturally some curious experimental fact. B. H.

942. *Experimental Proof of Spatial Quantelation in the Electric Field.* **O. Stern.** (Phys. Zeits. 23. pp. 476–481, Nov. 15 and Dec. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—A previous paper by Gerlach and Stern [see Abstract 1009 (1922)] contains a direct experimental proof of the presence of directive quantelation in the magnetic field, by which a ray of silver atoms passing through a non-homogeneous magnetic field was split up into 2 discrete rays corresponding to the two discrete positions which are possible on the quantum theory for a monoquantic atom in the magnetic field. The present paper seeks to find by means of an analogous experiment whether spatial quantelation is possible in the electric field. Based upon Bohr's work the theory of the non-homogeneous Stark-effect is developed and the importance of the anomalous effect measurements for the meaning of the anomalous Zeeman-effect considered. The broadening of lines and the fine structure are investigated with respect to the theory. Following this comes an examination of the effect of a non-homogeneous electric field on rays of hydrogen and alkali atoms respectively. There is found to occur a quite definite discrete force, and the molecular ray is split up into as many rays as there are different quantum states. The magnitude of the deviation is, however, very small, but under special experimental conditions it should be capable of measurement, although so far the author's experiments have not led to tangible results. H. H. Ho.

DISCHARGE AND OSCILLATIONS.

943. *Discharge Phenomena in Gases Exposed to a Tesla Current.* **H. Fischer.** (Zeits. phys. Chem. 104. pp. 74–89, 1923.)—Former investigations on the action of an electrical discharge on gases have generally been limited to the use of maximum voltages of about 50,000 at relatively low frequencies. In the present work a Tesla current is employed and the phenomena produced compared with a low-frequency discharge. The primary of a Rhumkorff coil was supplied with current at 150 volts and a periodicity of 800 cycles per minute. The energy of the current employed in the primary circuit was measured and controlled during each experiment. A secondary voltage of 25,000 volts thus obtained was supplied to the Tesla transformer after insertion in the circuit of a spark-gap consisting of copper plates of 8 cm. diameter, Leyden jars and a variable self-inductance. A wave meter was employed to enable resonance to be established between the two circuits, the wave-length applied being 370 metres. The secondary current from the Tesla coil led through a milliammeter to the terminals of the discharge tube, an electrometer being connected in parallel to this circuit. Luminescence phenomena were investigated with the gases oxygen, nitrogen, atmospheric air, hydrogen, and argon. The most noteworthy difference observed between the two types of discharge was in the case of hydrogen, the Tesla discharge giving an ultramarine light which gradually changed to the bluish-grey luminescence characteristic of the low-frequency discharge.

Ozone.—Parallel experiments on the formation of ozone from dried air and oxygen were made with Tesla current and alternating-current of 9200 volts and 800 cycles per minute frequency. For a given current in the primary the amount of ozone produced with the Tesla current was lower than with the low-frequency current. However, judging from the size of the luminous area, the energy expended in the discharge tube was less in the former case than in the latter. By employing an increasing number of plates in the spark-gap of the Tesla circuit, the luminous area increased together with an increase in the yield of ozone. A change of wave-length of the oscillating circuit had no appreciable influence on the ozone formation. On increasing the space between the concentric glass cylinders forming the electrodes of the ozoniser by diminishing the diameter of the inner cylinder, a large decrease in the ozone yield resulted. A similar decrease in the yield followed the use of a brass inner electrode in place of glass, while an aluminium vessel gave the same results as glass. With the Tesla discharge, on account of the heating of the vessel it is necessary to cool the inner surface of the central cylinder. The formation of traces of nitrogen pentoxide was established while the lower oxides of nitrogen were absent. By enriching the gas under treatment with oxygen, the yield of ozone was improved, but that of nitric acid was not appreciably affected. The concentration obtained of both ozone and nitric acid decreased rapidly with increase in the rate of flow of gas. J. N. P.

944. *Luminescence Centres and Changes of Gas Pressure during Electric Discharges in Spectral Tubes.* **L. Hamburger.** (Zeits. Elektrochem. 28. pp. 545–553, Dec. 1, 1922).—A previous paper [see Abstract 793

(1918)] is first referred to as containing the experimental data which point to the circumstance that during electric discharges in a spectral tube, alterations in the gas pressures at the anode and kathode may occur. These are due to the differences in properties between positive and negative ions to which Stark has ascribed two consequential effects: (*a*) The occurrence of phenomena due to the electric wind termed electrostriction; (*b*) mass transport by the electric current. The present paper deals with these effects between which a connection arises, since both are to be traced to ionic differences. The conclusions drawn are as follows: (1) The observed pressure effect has its main cause in the different number of molecules which arise by the discharge of the positive and negative ions at anode and kathode. The electrical wind plays only a very subordinate part, and the magnitude of the pressure changes depends mainly on the number, mass, charge, and mobility of the two kinds of ions, *i.e.* there is interdependence between the electric variables, the gas pressure, and the nature of the gas. By a study of the physical significance of the various factors the cause of the pressure effect has been determined, and the formulæ derived have been experimentally confirmed for particular cases. Consequences are also deduced which serve to support the theories of Child, Franck, Hertz, and Thomson with respect to electro-luminescence. The outer electrons of atoms are found to determine catalytic properties, and the admissibility of the assumption of loosened states in catalytic theory is supported by optical data. H. H. Ho.

945. *Photo-Electricity as a Function of Gas Content.* **W. Hallwachs, M. Sende,** and **H. Simon.** (Ann. d. Physik, 68. 6. pp. 551–552, Sept. 14, 1922.)—Reply to observations on a former paper on this subject [see Abstract 630 (1922)]. A. B. W.

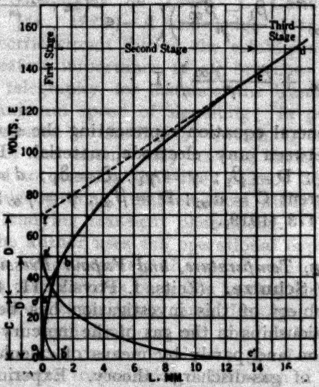
946. *The Extension Velocity of the Lichtenberg Figures and its Employment for the Measurement of very Short Intervals of Time.* **P. O. Pedersen.** (Ann. d. Physik, 69. 3. pp. 205–230, Nov. 16, 1922.)—A method has been described in an earlier publication [see Abstract 1092 (1920)] for the measurement of positive and negative Lichtenberg figures, and utilised for determining the average velocities in the vicinity of the electrodes, and for the retardation of electric sparks. The latter investigation is being continued and will be communicated subsequently. The present paper deals with the changes in velocity, from the electrode where it is greatest, to the extreme edge of the figure where it is zero. A theoretical discussion is postponed to a later paper. The problem dealt with now is essentially as follows: At a definite instant a Lichtenberg figure proceeds from an electrode and after t secs. its boundary is a distance r cm. from the electrode. These are connected by the equation $r = F(t)$, where the function F depends on the amplitude of the impulse, nature, and density of the gas, thickness of the photographic plate, etc., and the problem is to determine this function. Section 1 considers methods for measuring values of t and r. Section 2 derives the form and position of the boundary line when the impulse has an extremely steep front, and Section 3 subscribes an experimental proof for the contour obtained. In Section 4 the influence of a flat wave front upon the form of the contour is investigated. Section 5 deals with the general form of the boundary and affords an experimental proof for its partial rectilinear contour. Section 6 describes measurements of very short time intervals. The equations involved for the determination of F are found to possess the following forms: $r = \mathrm{R}(1 - e^{-at})$, $v = a\mathrm{R}e^{-at} = v_0e^{-at}$, $t = \frac{1}{a}\log\frac{\mathrm{R}}{\mathrm{R} - a}$, where v is the velocity. Values for the constants are given. H. H. Ho.

947. *The Low-Voltage Arc in Mercury Vapour and its Relation to Fluorescence.* **Y. T. Yao.** (Phys. Rev. 21. pp. 1–21, Jan., 1923.)—In spite of extensive work by various investigators [see Abstracts 204 and 434 (1919)] on low-voltage arcs in metallic vapours, of which mercury is typical, the question as to whence comes the energy requisite to produce ionisation at voltages less than the minimum ionising potentials remained unanswered until very recently. Using a simple tube with incandescent tungsten filament as kathode, and a relatively near mercury surface as anode, it is now found that an arc strikes at voltages as low as 4·4 and persists down to 1·8 volts if the pressure is from 2–5 mm. and the kathode is sufficiently hot. If, however, correction is made for the initial velocity distribution of the electrons, the minimum electron energy necessary to maintain the arc comes out at 5·5 volts, which is the difference between the ionisation potential, 10·4 volts, and the resonance potential, 4·9 volts. Ionisation is then effected by two successive impacts, at 4·9 and 5·5 volts, in agreement with the theory of K. T. Compton. When a nickel anode is used and the mercury surface is removed to a considerable distance, 70 to 180 cm., the arc cannot be maintained at a net voltage of 5·5, but 6·7 volts is required. This fact is demonstrated with three pieces of apparatus. This indicates that while freshly distilled mercury vapour, as is well known, is particularly active in fluorescent absorption of λ2536 radiation (4·9 volts), old vapour is more responsive to λ1849 radiation (6·7 volts). The difference between the theoretical and observed minimum striking voltages, 2·5 volts for sodium (Wood and Okano), and 2·0 volts for helium (Compton, Lilly, and Ohmstead), it is suggested is equal to the voltage equivalent to the minimum initial energy of the electrons which start the arc. A table is given from which the proportion of electrons having energies above any value for any filament temperature may be computed. A. E. G.

948. *On the Temperature of the Crater of some Arc Lamp Carbons and the Radiation of the Flame Arc between them.* **F. Patzelt.** (Zeits. techn. Physik, 4. 2. pp. 66–72, 1923.)—The present paper deals with the quantitative aspects of the arc lamp. These can only be investigated by means of a spectral analysis of the light emitted in order to find the selectivity of the radiation, and the experiments require a rigid investigation of the materials and methods employed. The latter form the subject of the first two sections, following which comes the separate treatment of the continuous spectrum of the crater and of the effective carbons, and finally intensity measurements in the arc light. The temperature of the electrodes appears undoubtedly to be dependent on the material and on the current strength. Two pure graphite carbons gave the highest black temperature, impurities in the kathode material reducing this appreciably. With a normal specific load of 0·746 amp./mm.^{2} this was 3775°, while in the Beck-effect it ranges up to 3900° abs. The negative carbon when purest gave a similar temperature to that of the positive crater, while an impure anode reduces this about 300°. An anode heated by external means to 1100° gave a uniform temperature decrease of 70° in all colours, as against an anode not so heated. Optically a sharp difference can be made between the continuous edge radiation and a selective discontinuous central radiation. Spectra poor in lines permitted pyrometry by means of the arc gas, without changing the grey character of the carbon radiation. In the normal arc a zone of higher intensity occurs just in front of the electrodes, which at the outset remains greater at the kathode, but in the Beck-effect only exists at the anode (in the positive flame). The characteristic phenomenon is the formation of a positive flame which discharges the negative ray and prevents the enveloping of the positive crater as in the ordinary effect. The temperature of the crater edge is thus raised and also a gas cloud of high specific intensity generated, which together produce an increased surface brightness. H. H. Ho.

949. *New Equation for the Static Characteristic of the Normal Electric Arc.* **W. B. Nottingham.** (Am. I.E.E., J. 42. pp. 12–19, Jan., 1923.)—The static characteristic is the relation between the current i flowing in the arc, the length L of the arc, and the difference of potential E across the arc, and is represented approximately by the Ayrton equation $E = a + b.L + \frac{c + d.L}{i}$, or the Steinmetz equation $E = a + \frac{c(L + d)}{i^{0 \cdot 5}}$, where a, b, c, d are constants. If the arc length is assumed to be constant, these equations can be written in the form

$$E = A + B/i^n \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$



where A and B are constants dependent on the arc length and the electrode material, and n is a constant dependent on the electrode material only. For the characteristic curves representing the arc between carbon electrodes $n = 1$; and between copper electrodes $n = 0 \cdot 670$. The exponent n of the current i in the equation (1) is directly proportional to the absolute temperature of the boiling-point or sublimation point, as the case may be, of the anode. The equation of the constant current curve is

$$\mathrm{E} = \mathrm{C} \,.\, (1 - \epsilon^{-d \,.\, \mathrm{L}}) + \mathrm{D} \,.\, (1 - \epsilon^{-d \,.\, \mathrm{L}}) + \gamma \,.\, \mathrm{L} \quad \ldots\ldots \quad (2)$$

In equations (1) and (2), by referring to the figure it will be seen that

$\mathrm{C} + \mathrm{D}$ = intercept of line *fd* on the E axis
C = intercept of curve *o′b′* on the E axis
D = intercept of curve *a′c′* on the E axis
γ = slope of line *fd*
$-\delta$ = slope of straight line represented by the equation $\log e_2 = \log \mathrm{D} - \delta \,.\, \mathrm{L}$
$-d$ = slope of straight line represented by the equation $\log e_1 = \log \mathrm{C} - d \,.\, \mathrm{L}$

By combining equations (1) and (2) the author obtains the empirical equation

$$\begin{aligned} \mathrm{E} = {} & \left(a_\infty + \frac{a_1 - a_\infty}{i^n}\right)(1 - \epsilon^{-d \,.\, \mathrm{L}}) \\ & + \left(\beta_\infty + \frac{\beta_1 - \beta_\infty}{i^n}\right)\left(1 - \epsilon^{-\left(\delta_\infty + \frac{\delta_1 - \delta_\infty}{i^n}\right) \,.\, \mathrm{L}}\right) \\ & + \left(\gamma_\infty + \frac{\gamma_1 - \gamma_\infty}{i^n}\right) \,.\, \mathrm{L} \end{aligned}$$

which is a truly general equation representing the static characteristics of normal arcs between any electrode material. For the curve of 1·0 ampere $\mathrm{C} = a_1$; $\mathrm{D} = \beta_1$; $\gamma = \gamma_1$; $\delta = \delta_1$; $d = d$; and for the curve of infinite current $\mathrm{C} = a_\infty$; $\mathrm{D} = \beta_\infty$; $\gamma = \gamma_\infty$; $\delta = \delta_\infty$; $d = d$. [See also Abstract 473 (1919).] T. C. H.

950. *Dissociation, Temperature, and Vapour Pressure in the Mercury Arc.* **A. Günther-Schulze.** (Zeits. f. Physik, 11. 4 and 5. pp. 260–283, 1922.)—The object of this investigation has been to obtain the conditions and relationships in the gas of the mercury-arc lamps, partly by direct observation and partly by means of calculations based upon present knowledge of gas-discharge theory. Experimental details are briefly described, and reference made to the method of Küch and Retschinsky [see Abstract 1607 (1906)] for measuring the vapour pressure of mercury-vapour in quartz lamps. In the lower part of the cool chamber of the glass vessel employed, the average velocity of the mercury-vapour which streamed in for condensation was $4 \cdot 5 \times 10^3$ cm./sec. at a full load (100 amp.), while the mercury-vapour pressure in the anode arms was at the same time 0·3 mm. Hg. The calculation of the temperature in the axis of the positive column of the arc gave values which varied according to the size of the vessel from 1000° C. (for a 10-amp. load) to about 10,000° C. (for a 500-amp. load). When a 50-period alternating-current was used, the temperature variations in the anode arms followed the current variations almost without retardation, although the density changes showed appreciable phase displacements. At constant vapour pressure the temperature of the positive column rose only slowly with the current. For a constant current and rising pressure the temperature decreased, passed through a minimum, and then increased with the pressure to high values. The degree of dissociation of the mercury-vapour for an average load was found to be of the order 10^{-4}. H. H. Ho.

951. *Verification of a New Formula by Lecher's Apparatus.* **D. Mazzotto.** (R. Accad. de Sci. Lit. ed Arte Modena, Mem. 13. Ser. 3. pp. 23–43, 1917.)—The author has made a special study of the vibrations obtained with Lecher's apparatus with varying the capacity of the condensers and the length of the primary filaments, and determining experimentally in each particular case not only the length of the fundamental wave but also that of its harmonics. The results are expressed graphically by means of certain lines called "nodal lines," one of which represents the fundamental vibration, the others the harmonic vibrations possible with a given apparatus. The object of the present paper is to call attention to results of verifications obtained with a formula which has enabled the author to construct a complete set of theoretical "nodal lines" comparable with those obtained experimentally. A. E. G.

952. *Electrical Oscillations on Lines.* **L. Cohen.** (Frank. Inst., J. 195. pp. 45–58, Jan., 1923.)—A knowledge of transient oscillations produced in an electric circuit during the establishment of the steady state is of the greatest importance in all branches of electrical engineering. In cable telegraphy, for instance, the transient effects govern the permissible maximum speed of signalling; in power transmission, the transients introduced in the line by switching or by other change of the conditions of the circuit may assume destructive proportions. The phenomena are so complex that they cannot be readily subjected to experimental investigation; mathematical analysis therefore forms the sole means of studying transient phenomena.

In this paper the author uses the operational expansion methods of Heaviside to obtain simultaneously the steady state and the transient voltage and current distributions on a line having uniformly distributed resistance, inductance, capacitance, and leakage conductance. The line is assumed to be earthed at one end and to have a known e.m.f. applied at the other. Two cases are solved: (i) when the applied e.m.f. is sinusoidal, as in power transmission; (ii) when it is constant, as in telegraphy. Finally, the case of an ocean telegraph cable, in which inductance and leakage are negligible, is considered and solved for both of the above conditions. The results are of great generality and importance, including as special cases the well-known solutions given by Kelvin. The paper is mathematical and should be consulted in the original for details of the method and solutions. B. H.

953. *Method for Obtaining High-Frequency Potentials of Known Phase-Difference.* **G. Gleissner.** (Jahrb. d. drahtl. Tele. 20. pp. 342–356, Nov., 1922. Extract of Dissertation, Munich.)—Two types of method are given for obtaining high-frequency potentials of given phase-difference. In the first type an ohmic resistance and an inductance coil are introduced in series in a high-frequency circuit, and the required potentials are obtained from the terminals of the resistance and the inductance respectively. By suitable adjustment of the values of the inductance and resistance practically any phase-difference from 0° to 90° can be obtained. In the second type the potentials are taken from two inductance coils connected one in each of two coupled circuits. The phase-difference of the potentials can be varied by altering the coupling, by the introduction of ohmic resistance, or by mistuning, or by combination of these methods; and a wide variation of phase-difference can be thus obtained. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

954. *Specific Resistance of Graphite.* **W. Geiss.** (Zeits. Elektrochem. 28. pp. 527–528, Dec. 1, 1922.)—The author criticises Ryschkewitsch's statement that the specific resistance of pure graphite can be calculated from his formula $\rho = ax + b$ for powders, where x is the reciprocal of the pressure, so that the x term becomes zero when the pressure becomes very large, making ρ for this state equal to b; or to 0·075 ohms per cm. cube [Abstract 996B (1922)]. F. Streintz has employed much higher pressures than Ryschkewitsch and obtained $\rho = 0{\cdot}0014$. Numbers have been found for various solid graphites by different observers, which vary from 0·00127 down to 0·00006, the last number being for a "metallised" carbon filament. This is of the same order as the specific resistance of metals, and it should be noted that the temperature coefficient of such a filament, like that of metals, is positive. In a note on this paper Ryschkewitsch states that he did not intend to apply his formula to the case where the grains of the powder are pressed into a solid mass. The constitution of the individual crystals must not be altered, and they must not be welded together by the pressure if his formula is to be used. H. N. A.

955. *Effect of Longitudinal Stress on the Electrical Resistance of Carbon Steels.* **S. Fukuta.** (Tôhoku Univ., Sci. Reports, 11. pp. 131–137, May, 1922. 61st Report of the Iron and Steel Research Inst. In English.)—The object of the work is to determine accurately the relation between electrical resistance and stretching force in rods of different kinds of steel over a range of longitudinal stress greater than that used in previous experiments. The composition of four Swedish steels, varying in carbon content from 0·3 % to 1·5 % of carbon, is given. These specimens are cylindrical rods (21 cm. long, 8 mm. diameter) with enlarged ends for fixing in the Olsen testing machine used for stretching the rods. The elongation of 9 cm. of the rod is found by an extensometer and the stress-strain curve is recorded automatically. To obtain the electrical resistance of the specimen a current of nearly 3 amp. is passed through the rod and the p.d. between two points measured. The diameter of the rod is obtained by a micrometer. These measurements are made for various values of the tension and from them the specific resistance of the material is calculated. It is found that the stress-strain and the stress-resistance curves are very similar. The curves showing the relation between change of specific resistance and stress are all nearly linear but bend slightly away from the stress-axis as the stress increases. For different steels these curves nearly coincide, their inclination to the stress-axis decreasing only very slightly with decrease in carbon content. There is no abnormal increase of specific resistance when yielding of the specimen occurs. The percentage increase of specific resistance is

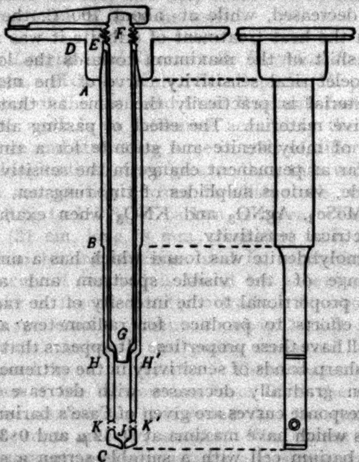
$1 \cdot 139 \times 10^{-6}$ for a stretching force of 1 kilogram per 1 cm.^{2} (mean for the steels used). T. H.

956. *Photoelectrical Investigations.* **W. W. Coblentz.** (Bureau of Standards, Bull. 18. pp. 585–607 [Sci. Papers No. 462], 1922.)—This paper gives miscellaneous results which were obtained in connection with the general investigation of photoelectrical sensitivity in various substances. Data are given on the preparation and testing of various sulphides of molybdenum, MoS_2, MoS_3, etc., the object being the artificial production of molybdenite, MoS_2, which is photoelectrically sensitive. The material examined was connected with a dry battery and a galvanometer. A vacuum tungsten lamp at a fixed distance from the sample was used as a standard source of radiation. When the substance, usually a poor conductor, is tested there is a galvanometer deflection caused by the "*dark current*." When exposed to radiation, if it is sensitive, there is an additional deflection caused by the "*light current*." The ratio of these is a measure of the photoelectrical sensitivity or of the "*photoelectrical efficiency*." The results obtained show that all the wet and dry process preparations of MoS_2 are photoelectrically sensitive, but much more sensitive spots are found in some samples of the natural mineral. It appears that the sensitivity is inherent in the MoS_2. Spectroscopic and qualitative chemical analysis shows no marked difference in the constituents of samples of molybdenite, excepting a larger iron content in the material having a high photoelectrical sensitivity. On raising the temperature it was found that slow heat treatment has no marked permanent effect upon the intrinsic sensitivity up to 500° C. At about 600° C. the sensitivity appears to be permanently decreased, while at about 700° C. the photosensitivity is destroyed. In the heat treatment of stibnite it was found that apart from a possible shift of the maximum towards the long wave-lengths the spectro-photoelectrical sensitivity curve of the melted and slowly recrystallised material is practically the same as that of the average curve of the native material. The effect of passing alternating current through samples of molybdenite and stibnite for a time was found to be negligible so far as permanent change in the sensitivity is concerned. Molybdenum oxide, various sulphides of tin, tungsten, and uranium, as well as Bi_2Te_3, $MoSe_3$, $AgNO_3$ and KNO_3 when examined showed no marked photoelectrical sensitivity.

A sample of molybdenite was found which has a uniform sensitivity over a wide range of the visible spectrum and a photoelectrical reaction which is proportional to the intensity of the radiation stimulus. This encourages efforts to produce for radiometers a photoelectrical material which will have these properties. It appears that molybdenite and stibnite have no sharp bands of sensitivity in the extreme ultra-violet, but that the reaction gradually decreases with decrease in wave-length. Several spectral response curves are given of Case's barium and strontium photoelectric cells which have maxima at $0 \cdot 42\,\mu$ and $0 \cdot 39\,\mu$ respectively. By covering the barium cell with a suitable screen a spectral response curve is obtained which coincides closely with the visual response of the average eye. Cuprous oxide was examined. Data obtained with Pb_3SbS_3 show that the spectro-photoelectrical reaction spectrum of a compound is not the composite of the reactions of the constituents which may be photoelectrically sensitive. Iodine was found to be photoelectrically sensitive with a maximum in the region of 0·53 μ to 0·55 μ. J. J. S.

957. *Piezo-Electricity.* **E. W. C. Russell and A. F. R. Cotton.** (El. Rev. 92. pp. 284–287, Feb. 23, 1923.)—Certain crystals, particularly those grown from Rochelle salt, are microphonic generators. The authors show in a drawing a crystal with a tinfoil girdle acting as one electrode, and the curious "hour-glass" structure; a formation that is piezo-electrically very active. From experiments it was discovered that the greatest efficiency was obtained by passing the pressure waves through the crystal so as to produce a "torsional effect," so to speak, *without any movement.* By this absence of movement the receiving surface can sustain much rough usage; and from the point of view of sound one of the greatest causes of distortion is removed. A piezo-electric gramophone reproducer is described, in which by using compressed cellulose acetate, or "celastoid," resonance waves are completely absorbed. A description is given of some of the applications of piezo-electric instruments, *e.g.* hydrophones. The effective range of piezophones is directly proportional to the amplification applied; in other words, the range extends along a flat curve with a sharply defined step for each extra valve used. One curious property of Rochelle-salt crystals (which are not hygroscopic) is that there is a permanent negative charge of about 1/20th volt across the two ends and the centre girdle. T. C. H.

958. *Quartz Fibre Suspension with Variable Control.* **C. Benedicks.** (Zeits. Instrumentenk. 42. pp. 367–372, Dec., 1922.)—Describes a method of galvanometer needle suspension which makes it possible to obtain a very easily adjustable control moment without the use of a magnetic field. The needle is suspended from a loop of fine quartz fibre the ends of which pass between the jaws J and are fixed one at



each of the holes K and K′. The separation of the jaws at J, which results in a gradual increase in the controlling force, is effected by rotation of the cylinder F. This rotation causes a slow motion of translation which, owing to the form of the cylinder at G, slightly separates the limbs H, H′. J. W. T. W.

959. *Conditions of Instability of the Differential Galvanometer.* **A. Sellerio.** (Elettrotecnica, 9. pp. 782–784, Dec. 5, 1922.)—In the course of certain experiments in which a differential galvanometer was employed, the author remarked that when the current in the coils exceeded a certain value the equilibrium of the needle became unstable. As a matter of fact, if the currents in the two coils were established when the needle was slightly deflected towards the right, the needle was further deflected towards the right; and if it was slightly deflected towards the left, it went further towards the left. The author studies this phenomenon analytically and compares it to that shown by a balance which, when the load exceeds a certain value, becomes unstable, because its centre of gravity is higher than the centre of oscillation. In any case, the phenomenon is rendered possible by the coils not being perfectly coaxial. E. B.

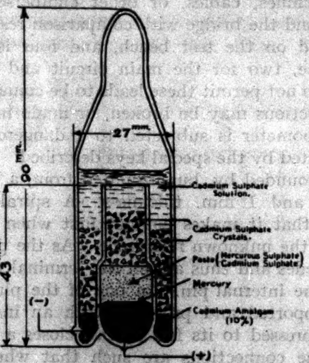
960. *Improved Contact Plugs for Use with the Thomson Bridge.* **H. Schering.** (Elekt. Zeits. 44. pp. 11–12, Jan. 4, 1923. From the Reichsanstalt.)—When using the Thomson bridge to measure small resistances in machines, cables, or other cumbersome equipment, the source of current and the bridge with comparison resistance and galvanometer are mounted on the test bench, and four leads are run to the unknown resistance, two for the main circuit and two for the bridge. If circumstances do not permit these leads to be connected in a permanent manner, the connections may be broken, or made in incorrect sequence, so that the galvanometer is subjected to a dangerously heavy current. This risk is eliminated by the special keys described. A copper pin 2 mm. in diameter is surrounded by, but insulated from, a brass tube of 4 mm. internal diameter and 1 mm. thickness. A spiral spring presses the tube forwards so that it makes contact first when the plug is applied to the terminal of the unknown resistance. As the plug is pressed down, the brass tube recedes and thus allows the terminal to come into contact with the end of the internal pin. In one of the plugs, the internal pin is itself spring-supported and provided with an insulated head which, when the plug is pressed to its full extent, closes a key in the galvanometer circuit. The connections are such that when the first plug is applied the main circuit (connected to the pin) cannot be closed until the bridge lead (connected to the outer tube) has been connected. The second plug makes the bridge circuit, main circuit, and galvanometer connections in the order stated. Disconnections are automatically made in the reverse sequence. The voltage drop at the main circuit connections does not enter into the measurement when these keys are used. The resistance of the plugs and their bridge leads is generally negligible. It has been found that, however carelessly the plugs are used and whatever the form of the surface to which they are applied, the connections are made and broken in the correct sequence. R. E. N.

961. *Measurement of Small Capacities by the Resonance-Suspension Method.* **W. Glitsch.** (Phys. Zeits. 23. pp. 544–548, Dec. 15, 1922.)—

The possibility by means of kathode tubes of producing oscillations of the greatest stability has enabled processes to be devised for the measurement of very small capacities and changes of capacity. Reference is made to the publications of Pungs and Preuner, Herweg, and Hammer on such processes. Each of the latter, as well as the one now described, depends on the principle that a particular oscillation frequency in an electrical system alters with capacity changes, so that the latter may be determined by means of the former. The experimental details are very fully described and the process adopted is very similar to that of Pungs and Preuner [see Abstract 618 (1920)]. Section 1 deals with procedure ; Section 2 discusses mathematically the measurement of capacities by an increase of normal capacity, and derives a formula thereto ; Section 3 gives details for the measurement of small self-inductions by the resonance-suspension method. The paper includes 7 diagrams showing the various experimental schemes employed.

H. H. Ho.

962. *Concentric Form of Standard Cells.* **Y. Ishibashi.** (Elektrot. Lab. Tôkyô, Researches, 113 [12 pp.], Aug., 1922. In English.)—The concentric form of standard cell proposed by C. J. Rodman and T. Spooner [see Abstract 1612 (1921)] has been modified by the author so as to make the instrument more convenient, as shown by the diagram. The chief advantage of this form of cell is that the two limbs cannot differ seriously in temperature. In the usual form the e.m.f. varies more than three parts in 10,000 for either the anode or the kathode if there is a difference of 1° C. between them.


90 mm.
27 mm.
43 mm.
Cadmium Sulphate Solution.
Cadmium Sulphate Crystals.
Paste (Mercurous Sulphate / Cadmium Sulphate)
Mercury
Cadmium Amalgam (10%)
(−)
(+)

W. R. C.

963. *Capacity Measurements at High Frequency.* **F. Bedeau.** (Onde Élec. 2. pp. 74–90, Feb., 1923.)—Capacities are measured against a standard cylindrical condenser, whose capacity can be accurately measured. The standard capacity, and the one to be measured, are connected in parallel in an oscillating triode assembly. Both capacities are so varied as to maintain the oscillation frequency constant. A complete mathematical discussion of the method for various conditions is given ; for which the original paper should be consulted. F. S. B.

964. *Kathode-Ray Oscillograph for the Study of Low, Medium, and High Frequencies.* **A. Dufour.** (Onde Élec. 1. pp. 638–663, Nov.; 699–715, Dec., 1922, and 2. pp. 19–42, Jan., 1923.)—A description is given of a high-voltage kathode-ray oscillograph which is employed in the study of a.c. wave-forms of all frequencies up to 10^7 cycles per second. The oscillograph is essentially a development of the Braun tube, but is adapted for photographic recordings as well as for visual observation. Methods of generating a true axis on the records are described. In the case of very low frequencies a mechanical method of translating the film is sufficient, but at higher frequencies the inertia factor becomes too serious, and it becomes necessary to resort to electrostatic and electromagnetic means of deflecting the pencil of kathode rays rapidly across the film. Excellent reproductions of records at all frequencies up to 220,000,000 per second. The oscillograph has obvious applications to high-frequency research as in wireless telegraphy, where the ordinary forms of oscillograph are quite useless. A. B. W.

965. *Portable Oscillograph.* **J. W. Legg.** (Am. I.E.E., J. 42. pp. 106–111, Feb., 1923.)—Modern developments in the electrical industry have shown the need for a reliable portable oscillograph such as is described in this paper. The instrument is a modification of an oscillograph outfit described by the writer at an earlier date [see Abstract 792 (1920)], but is of much less bulk and contains several novel features. The instrument, exclusive of film-holder and motor is contained in a micarta case 11″ × 11½″ × 25″ and weighs complete 100 lbs. It can be operated at any voltage from 110–220 volts a.c., or alternatively from a 6-volt battery when a.c. is not available. The necessary d.c. for the oscillograph magnet is derived from a "Rectigon" rectifying tube when the apparatus is used on a.c. mains. The galvanometer has three elements, having a sensitiveness of 1 in. deflection of light-spot for 0·1 ampere; an improved type of element with a permanent magnet has also been designed and renders unnecessary the rectifier and its auxiliary apparatus. The mirrors are illuminated by a small incandescent lamp operated at great intrinsic brilliancy by momentary abnormal voltage, the circuit of the lamp being automatically opened by the shutter mechanism after the oscillogram has been photographically recorded. The records are taken on standard Kodak 3A roll-film enclosed in a special daylight-loading film holder; the film is drawn along for each exposure by means of a motor drive which also operates the shutter mechanism and trip devices. Proper timing devices are provided so that transient phenomena can be recorded without waste of film. A special long-film camera for taking records of long duration has also been devised. The entire apparatus is self-contained, all the necessary resistances and shunts, control switches for the various ranges of current and voltage measurement, and also for the purpose of changing over from a.c. to d.c. operation are included in the case. The paper concludes with a series of oscillograms taken by the apparatus, and with suggested practical applications of the instrument. B. H.

ALTERNATING CURRENTS AND MAGNETISM.

966. *Harmonic Analyser.* **F. S. Dellenbaugh, Jr.** (Am. I.E.E., J. 42. pp. 58–61, Jan., 1923.)—Modern alternating-current investigations frequently require the harmonic analysis of wave-forms, some form of arithmetic ordinate method being generally adopted for the purpose. Where a large number of curves are to be analysed the amount of calculation required becomes very great and it is very advisable that the labour should be lightened by the use of some kind of analysing machine.

The machine described in the paper is based on a method of selected ordinates developed by Fischer-Hinnen, in which the curve is divided into a different number of portions for each harmonic, the number of parts being equal to the order of the harmonic. The value of a particular harmonic may then be found by averaging the ordinates at the different points given by the division of the curve into parts. In principle the machine has a bar provided with a series of notches corresponding to the divisions of a half period of the curve plotted to a standard base length; an index with cross lines slides on the bar and has a spring operated dog which engages with the notches in the bar, the latter lying parallel to the axis of abscissæ of the curve. The bar is held in a carriage which can be traversed parallel to the axis of ordinates and has a magnetic clutch which engages with a scale. The curve to be analysed is placed on a platen below the bar and carriage, the dog is moved from notch to notch and the cross lines brought into alignment with the curve. At each setting the magnetic clutch is operated so that successive ordinates are alternately added and subtracted—as the theory of the method requires—the scale reading giving the harmonics corresponding to the number of notches in use. The theory of the method is given together with a tabular form for the use of the instrument. It is shown that the time required to perform an analysis compares favourably with that required by other devices. B. H.

967. *Magnetic Initial Permeability, Apparent Hysteresis, and Behaviour under Vibration.* **J. Würschmidt.** (Zeits. f. Physik, 12. 3 and 4. pp. 128–164, 1922.)—The difficult problem of the magnetic behaviour of different kinds of iron under the influence of very weak fields, *i.e.* the magnitude of the initial permeability has recently come prominently to the fore in practice, while theoretically the work of Gumlich, Gans, Steinhaus, etc., requires its practical elucidation. Gumlich [see Abstract 525 (1911)] has attempted to find the influence of the residual magnetism of an earlier magnetisation cycle on the initial permeability, and the present author gives the following extract of his conclusions: To small maximum permeability corresponds also a small initial value; the latter is small with material possessing small retention; for a high maximum permeability a high initial one does not always occur; after red heat the initial value is generally increased; the addition of silicon increases initial permeability considerably. The object of the present paper is to investigate closely the possible changes of initial permeability for a large variety of iron compositions. Section 1 describes the experimental arrangements and mode of calculation; Section 2 investigates soft iron and different brands of steel; Section 3 gives a comparison survey of the initial permeabilities of various kinds of steel and in particular of various nickel steels. No less than 39 tables of data are included. The residual magnetism may be increased or decreased by vibrations according to the particular metal in question. With iron which is not too soft, a suitable degree of vibration will bring about a re-magnetisation which has been quantitatively investigated. With very soft varieties of iron no field is produced when simultaneous vibration accompanies the magnetisation, so long as the external field strengths are small. By this means a method is offered for the determination of demagnetisation factors. Nickel steel of 29–36 %, particularly after red heat, exhibits an initial permeability of 1000–2000, *i.e.* 2–4 times as great as 5 % silicon steel which has hitherto possessed the highest value. Since the specific resistance of this nickel steel is also high, it has preference over other kinds of steel for many technical purposes, *e.g.* telephony and telegraphy. H. H. Ho.

968. *Dissymmetrical Electrical Conducting Networks.* **A. E. Kennelly.** (Am. I.E.E., J. **42.** pp. 112–122, Feb., 1923.)—It is well known that a symmetrical T connection formed of two equal impedances joining two terminals a and b and earthed at their common point through a third impedance, can be replaced at a given frequency by a symmetrical π connection of impedances of easily calculable value, the two vertical impedances being equal. Moreover, each of these equivalent systems can be replaced by a smooth line having distributed series impedance in its conductor and a leakage admittance between the latter and earth. Consequently, both the T and the equivalent π can be said to possess a certain hyperbolic angle θ and a surge or characteristic impedance Z_0 equal to that of the equivalent line. The paper than goes on to consider the properties of unsymmetrical T and π connections of impedances and their equivalent smooth lines. Two ways of reducing these networks are fully discussed. In the first, the dissymmetrical T is made symmetrical with respect to the terminals by making the two upper arms equal and applying a terminal series load. In the same manner an unsymmetrical π is made into a symmetrical π by the provision of a terminal parallel load. The systems then offer a certain hyperbolic angle θ, have surge impedance Z_0, and have a terminal load with an auxiliary angle θ. In the second method the dissymmetrical network is reduced by the following process. Measurements are made between each end terminal and earth in turn to find the surge impedances Z_{oa}, Z_{ob} for each pair of terminals. The T or π is then replaced by a smooth line, offering the same hyperbolic angle θ as measured from each end and characterised by a "geomean surge impedance" $Z_{ab} = \sqrt{Z_{oa}Z_{ob}}$ and an "inequality ratio" $q = \sqrt{Z_{oa}/Z_{ob}}$, to which the usual formulæ apply. The paper contains full details of the calculations, tables of formulæ, and a short bibliography. B. H.

969. *Magneto-Elastic Effect.* **K. Zschiesche.** (Zeits. f. Physik, 11. 4 and 5. pp. 201–214, 1922.)—The observations of Gerlach and Lertes on the Barkhausen effect [Abstract 1834 (1921)] are extended to Heusler alloys and iron-nickel alloys, their method being modified by the substitution of a valve for the rectifying crystal. Of four Heusler bronzes, only those with high susceptibility gave the effect, and that somewhat feebly. With a series of iron-nickel specimens the saturation intensity of magnetisation as dependent on the percentage of nickel is first determined [see also Abstract 1011 (1920)] after annealing, after cooling in liquid air, and at the temperature of liquid air. The remanence and coercive force are greatest in those alloys which contain from 25 to 30

per cent. Ni; the magneto-elastic effect is greatest for alloys containing about 20 per cent. Ni, and varies with the hysteresis loss of the specimen. The magneto-elastic effect may be produced by purely mechanical means, *viz.* by stretching an iron wire beyond its elastic limit; no such effect was found in nickel or chrome-nickel wires; torsion also fails to produce the effect. The changes in the effect caused by varying tension, torsion, and by circular magnetisation are also investigated. The author concludes that this effect is in all respects one of magnetostriction.
G. E. A.

970. *Magnetisation of Steel under Tension.* **L. Fraichet.** (Rev. de Mét. 20. pp. 32–45, Jan., 1923.)—This article is a study of the magnetisation of steel bars in a constant field while undergoing extension. A bar is placed in the testing machine and stretched at a constant rate; it is wound with primary and secondary coils, one producing a constant field, the other connected to a galvanometer, the deflection in which is shown to be proportional to the rate of change of flux with stretch. Photographic records are obtained of the deflection in terms of the time, up to the point of rupture. These indicate an increase in the deflection from zero to a maximum, then a decrease at about the same rate, the elastic limit being reached before the deflection becomes zero; the deflection reaches a small negative value which is practically constant until rupture takes place. The foregoing describes the behaviour of a tempered semi-mild steel; other examples are given, and the effects are discussed at length.
G. E. A.

971. *Paramagnetism and Atomic Structure.* **B. Cabrera.** (J. de Physique et le Radium, 3. pp. 443–460, Dec., 1922.)—An obstacle to rapid progress lies in the fact that paramagnetism is not a general property of matter as is the case with diamagnetism. A critical examination of the magnetic moments of the elements in the cation state is first made, the moment being a maximum in this state. From a discussion of the members of the iron group, the author concludes that the Weiss magneton is a real common measure of the atomic moments of simple ions, and that the magnetic moment of the ions is independent of the degree of dissociation of the salt. It is evident that the atomic moment is caused by electrons which describe closed orbits; but the nucleus may be set aside, also those electrons which take part in the production of the K and L spectra of the X-rays. Each spectrum characterises a group of similar orbits, and the atom may be supposed to be divided into shells or strata in each of which is localised one group of orbits; each stratum makes its appearance at the beginning of the corresponding period. The superficial region of the atom is the stratum N for members of the iron group; the N electrons are divided into two substrata, an inner one N_1, and an outer N_2 which contains valency electrons. The latter exists in all the elements of the period, but the former appears only about Ti. The N_1 charge increases from Ti‴ to Cu′ in which it reaches its maximum value, remaining constant for the following elements. The characteristic of these elements is that the electrons which are progressively added are not surface electrons as in the inner strata, but penetrate more deeply. The N_2 electrons do not take part in producing magnetic moment. A table is given showing the numbers of electrons in the different zones for the Fe group. The number of magnetons is plotted against the N_1 electrons and the graph brings out that the number of magnetons is exclusively a function of the number of electrons. The graph also gives a susceptibility 8 for Ti''', the value found by Wedekind and Hansknecht being 8·6. A discussion of the properties of some oxides of the group follows. [See also Abstract 1528 (1921).] G. E. A.

972. *The Gyro-Magnetic Effect.* **A. P. Chattock and L. F. Bates.** (Roy. Soc., Phil. Trans. 223. pp. 257–288, Dec. 13, 1922.)—On the assumption that the magnetism of ferro-magnetic bodies is due to the rotation of systems of electric charges, Richardson has shown that the angular momentum due to recoil for unit change in magnetic moment is given by $2m/e$. For electrons this is $1 \cdot 13 \times 10^{-7}$. The actual value is investigated for various specimens of iron and for nickel. A ballistic method is used, the specimens being cylinders about 10 cm. long and less than a millimetre diameter, suspended axially by a quartz fibre. Errors due to residual magnetism, eddy-currents, and inclination of the magnetic axis are specially dealt with. The mean result for all materials dealt with is that the coefficient is exactly one half that predicted if the charges concerned are electrons. A balanced resonance method is outlined, and its application to the Heusler alloys suggested. A. Wh.

973. *Unipolar Induction.* **A. Stefanini.** (N. Cimento, 24. pp. 35–38, July–Aug.–Sept., 1922.)—Other experimental arrangements are here described for the purpose of investigating the cause of unipolar induction. From a previous paper it would appear useless to expect experiments on the stability, or not, of the lines of force to throw any light upon the matter. A. E. G.

974. *A Simple Method for Determining Hysteresis Loss; with Notes on Relations between Magnetic Constants.* **E. Gumlich.** (Elekt. Zeits. 44. pp. 81–83, Jan. 25, 1923. From the Reichsanstalt.)—The author has investigated and improved upon a formula originated by Anderson and Lance [Abstract 85 (1923)] for the calculation of hysteresis loss from the maximum induction and the corresponding coercive force. As given by Anderson and Lance, the formula is: $W_h = aB_mH_c$; where W_h = hysteresis loss in ergs/cm.^{3}; B_m = maximum induction; H_c = coercive force; and $a = 0 \cdot 2133 + 0 \cdot 01082 \times 10^{-3}B_m$. In this form, the expression for W_h is not applicable to high values of induction because when saturation is approached W_h and H_c become constant, but B_m and a continue to increase. Also, due to differences between materials, the hysteresis loop broadens to a greater or less extent in the neighbourhood of the knee and the value of W_h may vary widely though H_c and B_m be the same. The author's tests on dynamo core plates show that a does not vary linearly with B_m, but rather according to the equation: $a = 0 \cdot 225 + 0 \cdot 000889 \times 10^{-3}B\,._m + 0 \cdot 000861 \times 10^{-6} \,.\, B_m^2$. Values for the coefficient a up to $B_m = 18{,}000$ are given in the original. The improved formula is sufficiently accurate for purposes of approximate estimates. No single formula can be applicable to both hard and soft material.

The following relations, determined experimentally, are used in the Reichsanstalt. For normal magnetisation curves of uniform material, the remanence of which lies between 5000 and 12,000: $\mu_{max.} = kB_r/H_c$ very nearly; where $\mu_{max.}$ = maximum permeability; B_r = remanence

corresponding to a high magnetisation; H_c = corresponding coercive force; and $k = 0\cdot476 + 0\cdot00568\,H_c$. For the smaller values of H_c, it is permissible to take $k = 0\cdot5$. The field strength corresponding to maximum permeability is approximately $1\cdot3\,H_c$. From these expressions it follows that the induction $B_{\mu:\max.}$ corresponding to maximum permeability is given by: $B_{\mu:\max.} = 1\cdot3(0\cdot476 + 0\cdot0057\,H_c)B_r$; and can be determined without plotting the actual permeability curve. For soft materials it may be taken that $B_{\mu:\max.} = 0\cdot62\,B_r$ but for cast iron and hard steel, the complete formula must be used. Comparisons between calculated and observed values for $B_{\mu:\max.}$ show that the formula gives results accurate within ± 5 % (often considerably closer).
R. E. N.

975. *Equations of the Magnetic Circuit.* **F. M. Gentry.** (Gen. El. Rev. 26. pp. 108–109, Feb., 1923.)—The solution of problems in which magnetic circuits composed of materials having different permeabilities are involved is rather a tedious matter, owing to the process of trial and error usually employed. The author derives empirical equations capable of giving a direct solution for simple magnetic circuits with an accuracy sufficient for all practical purposes. Starting with the case of an annular magnetic circuit of ferro-magnetic material having a constant area A, and including an air-gap of length l_g, the flux ϕ produced by ampere-turns NI is $\phi = 0\cdot4\pi\mathrm{NIA}\Big/\left(l_g + \frac{l_s}{\mu_s}\right)$, where l_s and μ_s are the length and permeability of the iron path. Assuming Fröhlich's equation $1/\mu_s = a(\mathrm{NI}_s/l_s) + b$, where NI_s is the number of ampere-turns expended over the iron part, and a, b are tabulated constants, the author is led to a quadratic equation for ϕ or a linear equation for NI. The same method is applied to find the solution for a magnetic circuit (i) without an air-gap; (ii) with two regions of the same material but of different section and length; (iii) for two regions of equal area but different materials; and (iv) for the general case of two regions of different lengths, areas, and permeabilities. The approximations are valid for values lying between 10 and 200 ampere-turns per inch.
B. H.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

976. *Imitation of Electrophysiological Current Generation.* **R. Beutner.** (Zeits. Elektrochem. 28. pp. 483–489, Dec. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig., Sept., 1922.)—The object of this paper is to explain the causes of the production of currents in living tissues. By this is to be understood the experimental exploration of the causes by means of artificial imitations of all details of the phenomena, so far as is possible, and tracing these back to general physico-chemical laws. As a detailed account of all the experiments is considered too lengthy, an attempt is here made to trace the steps by which this work has developed. For this purpose the paper is divided into the following sections: (1) Ascertaining the electrophysical concentration action, (2) Artificial imitation of the concentration effects, (3) Application of known physico-chemical laws to the observed phenomena, (4) Other kinds of oil-series and their relation to electrophysiology, (5) The cause of injurious currents, (6) The diversity of the specific electromotor action of artificial oil-series.
A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

977. *Crystallisation through Friction by a Glass Rod on the Walls of a Vessel.* (Remarks on the reply of Fricke.) **L. Dede.** (Zeits. Elektrochem. 28. p. 543, Dec. 1, 1922.)—The author states that he has only just seen Fricke's communication (*ibid.* pp. 244–245, May 1, and pp. 365–366, Sept. 1, 1922) on the subject of crystallisation as induced by glass friction. He objects to Fricke's conclusion that the fine glass particles generated by friction act as seeding for crystallisation nuclei, and states that in some experiments using $MgNH_4PO_4$ where glass suspensions were present then no crystallisation ensued, whereas this was induced to take place by tipping the rod with rubber tube, the function of which latter Fricke has apparently failed to comprehend. It is true an electrical explanation is forthcoming in his reply, but Dede points out this to be incompatible with the original assertions. A further error is exposed in that Fricke applies laws which are valid for suspensions to solutions devoid of them. (See also *ibid.*, 29. p. 46, Jan. 1, 1923.) H. H. Ho.

978. *Absorption of Mists Formed during Chemical Reactions.* **H. Remy.** (Zeits. Elektrochem. 28. pp. 467–469, Nov. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—Some mists and fumes formed during chemical reactions are not readily absorbed by water. These are not only fumes of substances like ammonium chloride, which have a negative heat of solution, but also substances like SO_3 with positive heat of solution. Technically, sulphur trioxide is absorbed by sulphuric acid of 98 %. In explanation Sackur suggested polymerisation of SO_3 in the presence of water-vapour [Abstract 1137 (1902)]; Küster (1904) believed that highly-concentrated solutions were better absorbents of their own solute than diluted solutions or water. The author finds that the superior absorption of SO_3 by H_2SO_4 is partly apparent; the visible mists disappear, but reappear on further passing the fumes through water; in the contact sulphuric acid process the gases are not dry. Similar experiments are made with ammonium sulphate, sodium peroxide, and phosphorus pentoxide. It would appear that moist visible vapours are best absorbed by water, but their dry, almost invisible dusts (having smaller particles, 10^{-5} cm. against 10^{-4} cm.) are best absorbed by their own concentrated solutions. Polymerisation may play a part in the phenomena. H. B.

979. *Occlusion of Hydrogen by Palladium.* **M. Yamada.** (Phil. Mag. 45. pp. 241–243, Jan., 1923.)—By means of X-ray analysis determinations have been made of the crystalline structure of palladium containing large proportions of adsorbed hydrogen. The figures obtained show virtually no difference from those for pure palladium other than slight contractions of the intervals between the lines on the röntgenogram; such contractions correspond with uniform expansions of the space lattices. Direct measurement of the expansion of the lattice gives the value 2·9 per cent., calculation from the displacement of the lines giving 2·8 per cent. Absence of new lines indicates that the hydrogen and palladium do not unite to form a compound. Support is thus accorded to the view that the hydrogen is adsorbed as a solid solution. T. H. P.

980. *Gas Adsorption at Ultramicroscopic Particles.* **M. König.** (Zeits. f. Physik, 11. 4 and 5. pp. 253–259, 1922. Extract of Dissertation, Stuttgart.)—According to recent work it has been established that Ehrenhaft's low values for the electric element charge [see Abstract 879 (1921)] are only apparent. Bär has concluded that for all deviations from the spherical form, the charge on particles may appear smaller than is actually the case. Changes of density have been likewise established by Radel for mercury, and as an explanation of the phenomena Regener has proposed that in this case a layer of dense gas about the charged particle may be the cause of the apparent discrepancy which apparently commences at a definite radius. Since the gas layer is of very small thickness its influence on large particles is not noticed, but when this thickness becomes comparable with the radius the effect becomes prominent and measurable. The present investigation starts on the assumption that in a gas which forms layers more readily than air, *e.g.* CO_2, these layers are of greater thickness and the discrepancies will in consequence be more pronounced. The experimental arrangements were similar to those of Radel [see Abstracts 699 (1921)] with suitable modifications which are described. The calculated value of the electric charge on mercury particles according to Stokes-Cunningham is apparently a function of the radius. From a definite radius onwards this charge value rapidly falls and the limiting radius is found to depend on the particular gas in which the mercury particles are immersed, *e.g.* in air it is about $1 \cdot 2 \times 10^{-5}$ cm., in CO_2 $2 \cdot 1 \times 10^{-5}$ cm. This difference shows that the adsorbed gas layer is thicker for CO_2 than air by some units $\times 10^{-6}$ cm., and occupies the space of many molecules. Regener's hypothesis thus receives experimental support.
H. H. Ho.

981. *Measurements on Adsorption at Metallic Surfaces.* **H. v. Euler.** (Zeits. Elektrochem. 28. pp. 446–449, Nov. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—The results are given of measurements of the adsorption of the silver ion from solutions of silver nitrate by gold and silver foil [see Abstracts 1747 (1922)]. The curves obtained in the two cases are of similar form, the maximum amounts of silver adsorbed per sq. metre being 5·5 mg. by gold and 8·5 to 9·0 mg. by silver; the adsorption is the same for polished as for etched surfaces. On the supposition that the adsorbed atoms form a layer one molecule in thickness, the diameter of such atoms is calculated to be either $1 \cdot 4 \times 10^{-8}$ cm. or $1 \cdot 8 \times 10^{-8}$ cm. according as the adsorbing surface is silver or gold. The smallness of these values, in comparison with Lorenz's value, $2 \cdot 8 \times 10^{-8}$ cm., for the diameter of the silver ion, and with the value, $4 \cdot 06 \times 10^{-8}$ cm., corresponding with the lattice constants found by Vegard, is perhaps the result of unevenness of surface even with the polished metal.
T. H. P.

982. *Adsorption of Ions by Manganese Dioxide.* **P. B. Ganguly** and **N. R. Dhar.** (J. Phys. Chem. 26. pp. 836–844, Dec., 1922.)—Experiments were made to determine the adsorption of ions by manganese dioxide when freshly precipitated. The electrolyte under examination was added to the solution of potassium permanganate and then a solution of manganous sulphate, equivalent to the potassium permanganate, was added, and the mixture shaken. The precipitate was filtered and washed until the filtrate was clear of all traces of the electrolyte, and the cation content of the total filtrate was then determined by suitable methods. It was found that the coagulative powers of different electrolytes, as calculated from the percentage of cation adsorbed from nearly normal solutions of the electrolytes by manganese dioxide, only partially obey the Schultze-Hardy law. Abnormally high percentages of ferric ions are adsorbed by manganese dioxide, which is probably due to the partial decomposition of the salts with the formation of ferric hydroxide. F. J. B.

983. *Rigidity of Gels. Influence of a Cristalloid in Solution.* **F. Michaud.** (Comptes Rendus, 175. pp. 1196–1198, Dec. 11, 1922.)—To ascertain the influence of a body in solution, mineral or organic, on the modulus of rigidity of a gel, the author used the method recently described [see Abstract 2042 (1922)] which admits of measuring moduli 130 times smaller than those previously determined by Schwedof. To mark the deformations of the gel the grains of gamboge, liable to attack by certain substances in solution, were replaced by grains of purified animal charcoal, which did not affect its rigidity. Some 200 measurements were made. The dissolved bodies were introduced into the hot solution, which was then allowed to jellify by cooling. Acids and bases caused a great reduction of rigidity of gelose or gelatin gels. This is, however, a mass-effect not to be confused with the phenomena of adsorption of the hydrogen ions investigated by the new American physico-biological school. A strong acid added sparingly to a consistent gelatin gel has a greater effect, given equal molecular concentration, than a strong base. With a very diluted gel the effect is reversed. The dissymmetry between the action of acids and bases is shown in a difference of the curves; the action of the acid is almost linear, that of the base rather parabolic. Hence if to a concentrated gel an acid or a base be added in an increasing quantity, the base will in the end act more strongly, molecular concentration being equal, than the acid. In the case of gelose gels the curves are reversed; the action of the base is linear, that of the acid parabolic. The author endeavours to interpret these facts in the light of the theory of gels established by Loeb (see "Colloids," by J. Duclaux). Gelatin is an amphoteric electrolyte which acts like a weak acid with bases and a weak base with acids, thus having at once an acid and a basic function, the former being the stronger. This explains the period of hesitation at the outset of the action of a base: first there is neutralisation, the lowering of rigidity setting in only when alkalinity has been achieved. On the other hand an acid, in the presence of gelatin which is in itself electro-negative, acts more freely and regularly. Further, it is found that soda, for instance, lowers the modulus of rigidity of sodium gelatinate more than hydrochloric acid that of gelatin chloride. The result is that the base, liberally added, produces finally a greater molecular weakening than the acid. In the case of very dilute gels, neutralisation is immediate, the base thus acting at the outset more strongly than the acid. Gelose shows a reverse behaviour, pointing to the conclusion that its basic is stronger than its acid function.

Action of Mineral Salts.—As was to be foreseen from the preceding, the action of a mineral salt depends on its state of hydrolysis. In the case of a non-hydrolised salt the molecular lowering of rigidity is about one-tenth that of an acid or base.

Action of Organic Substances.—Very variable. Saccharose, dextrose, levulose, mannite, glycerin barely act on gelatin or gelose gels. Urea, urethane, acetamide approximate in their action to a mineral salt. The lowering action of resorcin, hydroquinone, and tannin is enormous compared with that of an acid or base. E. F.

984. *Activation of Contact Platinum by Röntgen Rays.* **R. Schwarz** and **M. Klingenfuss.** (Zeits. Elektrochem. 28. pp. 472–473, Nov. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—Schwarz had observed (Ber. Deut. Chem. Ges. 55. pp. 1040–1051, 1922) that Röntgen rays retarded the catalytic action of colloidal platinum on hydrogen peroxide and on catalase, but that the platinum recovered in 16 hours or less. The authors continue the research by studying the action of the rays on platinum in the sulphuric-acid contact process. The platinum asbestos is placed in a quartz tube and exposed to the rays from a Lilienfeld bulb with tungsten target for about 2 hours, while a current of moist air passes through the tube. Dry air and moist SO_2 are then passed through the tube, which is heated to 260° and 400°. The ordinary efficiency of the conversion by the platinum of SO_2 into SO_3 was 94·6 %; after exposure to the rays the efficiency rose to 95·9 % at 400°; at 260° the figures were 35 and 51 % (after exposure). The increased catalytic effect lasted 24 hours, but the efficiency first decreased (below the average) and then rose again during this period. When the platinum asbestos was heated to 400° before the exposure to the rays in a current of perfectly dry air, no effect was observed. The presence of water is hence necessary for this activation, as it is for the oxidation of SO_2. H. B.

985. *Mesomorphic States of Matter.* **G. Friedel.** (Ann. de Physique. 18. pp. 273–474, Nov.–Dec., 1922.)—The author describes as "mesomorphic states" the two conditions which have hitherto been commonly described as liquid crystals. The two forms are distinguished as *smectic* (from σμηγμα = soap) and *nematic* (from νημα = a thread), corresponding with Lehmann's "fliessende krystalle," and "flüssige krystalle," or the French classification into "liquides à coniques" and "liquides à fils." The former, with its waxy consistency, is regarded as almost a normal condition for the soaps, whilst the latter is characteristic of azoxyphenetol, etc. The properties of these two states of matter are described in detail, and illustrated by 30 very beautiful photographs; but, since an outline of many of the facts has been given in papers by Manguin, Friedel, and Grandjean, the reader is advised to study the original paper, which forms a masterly review of recent work on this important subject. T. M. L.

986. *Crystal Formation in Colloidal Metals.* **V. Kohlschütter** and **K. Steck.** (Zeits. Elektrochem. 28. pp. 554–568, Dec. 1, 1922.)—The formation of metal crystals in colloidal metal solutions was studied. Experiments were made with Lea's silver solution, with collargol and electrargol, which were stored in stoppered tubes, placed out of direct light, and were examined microscopically every two or three weeks for fourteen months. The reactions

$$Ag + Fe^{+++} \rightleftharpoons Ag^{+} + Fe^{++}$$

and

$$Ag + Ag^{+} \rightleftharpoons Ag_2^{+}$$

were studied and the effect of concentration and other salts were investigated. The results showed that in colloidal silver solutions silver crystals are formed, partly owing to the difference in solubility of different-sized particles, and also to the ultramicroscopic particles collecting to form a crystal, in consequence of a molecular field. Experiments showed that Lea's sol gave rise to crystals during 18 months, and in pure sols, which were formed by the reduction of silver oxide by hydrogen, the crystal formation could only be demonstrated in a 12-year-old solution. By the action of Fe^{+++} or Ag^{+} ions on a coagulated gel and other silver salts, polyhedral crystals were obtained, and by the reduction of Ag^{+} solutions with Fe^{++}, whereby colloidal solutions of the former metal are obtained form crystals at certain concentrations. Localising the reaction by using solid Fe^{++} compounds in Ag^{+} solutions, and solid Ag^{+} compounds in Fe^{++} solutions, favoured the formation of crystals. F. J. B.

987. *Analysis of Liquid Mixtures of Organic Bodies by the Interferometer.* **E. Cohen** and **H. R. Bruins.** (Zeits. phys. Chem. 103. pp. 337–348, Jan. 15, 1923.)—The water interferometer of Rayleigh-Löwe, by Zeiss, is adapted for the analysis of very dilute solutions in organic liquids. A parallel beam of light is passed longitudinally through two adjacent cells containing similar liquids, the ends being closed with optically-worked glass plates. By means of a mirror at the far end of the apparatus and two slit diaphragms, narrow beams of light are reflected back again through the respective cells, then united by a lens so as to form two superimposed interference images in the eyepiece. A variation in refractive index of one of the liquids in the cells causes a displacement sideways of the interference bands. By inserting obliquely-placed plates of glass in the paths of the rays, the optical path is shortened and by adjusting the angle of inclination of the plate small changes of refractive index of the liquids can be compensated so as to cause the interference bands to coincide and the change of refractive index is thus measured in terms of the angle of inclination of the interposed plate. The concentrations of the solution is taken as a function of the scale divisions representing the rotation of the compensator. With solutions of high concentrations it is necessary to apply a correction for the difference in dispersion of solution and solvent which causes a deviation of the central interference line. A discussion is given of the precautions necessary to avoid the main sources of error such as temperature variations and absorption of water. The apparatus has been applied to measurements on diffusion velocities. J. N. P.

988. *Constitution of Aqueous Solutions of Thallium Salts.* **C. Drucker.** (Zeits. Elektrochem. 28. pp. 463–467, Nov. 1, 1922. Paper read at Deut. Bunsen Gesell., Sept., 1922.)—Having found the surprisingly high mobility value 116 for the ion $TlSO_4'$, the author investigates the thallous nitrate $TlNO_3$ which should show very little formation of complex anions in diluted solutions. The solution contains $TlNO_3$, $Tl^{\cdot}$, NO_3', $Tl^{\cdot\cdot}$. The experiments concern freezing-point depressions, concentration cells of thallium amalgam and the nitrate, transference numbers and conductivity and density measurements. The solution is found to contain appreciable proportions of $Tl^{\cdot\cdot}$; Ostwald's dissociation rule is confirmed. The recalculations of the mobility of $TlSO_4'$ (from $2Tl^{\cdot} = Tl_2^{\cdot\cdot}$) shows, however, that the mobility is normal, about 60. In a postscript the author criticises

Ghosh's formula for the connection between conductivity and concentration. H. B.

989. *Application of Nernst's Heat Theorem to Dilute Solutions.* **K. F. Herzfeld** and **K. Fischer.** (Zeits. Elektrochem. 28. pp. 460–463, Nov. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—The authors discuss the extension of Nernst's theorem, so far restricted to gases and solids, to dilute solutions. The calculations involve the determination of G, the bound energy of the molar solution. In the case of ions the solution pressure of the metal or normal potential corresponds to the vapour pressure of the gas, and the solubility of sparingly-soluble salts, which are used for the calculation of G, to the dissociation pressure; Ag^+ is adopted as normal ion. The variation of the specific heat of the metal or of the solid salt must be known. It is confirmed that in the halogen salts (of Tl, Pb, Ag) the solubility changes with the heat of solution. The heat of solution of gases in water seems to depend upon the merely physical orientation of the water molecules and is hence much influenced by temperature changes; in other words, the dielectric constant depends upon temperature. The heat of hydration (there identical with the heat of solution) is closely connected with G. One may say that G measures the space which is at the disposal of an atom (Fajans), a negative G diminishing the mobility range. When the heat of hydration is large, many water molecules have to be directed, and their rotational mobility is hence restricted. H. B.

990. *Cultivation of Metal Crystals from the Gaseous Phase.* **F. Koref.** (Zeits. Elektrochem. 28. pp. 511–517, Dec. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—Tungsten crystals were grown on a wire consisting of a single crystal [see W. Böttger, Zeits. Elektrochem. 23. p. 121, 1917] by heating the wire (by passing a current through it) in a mixture of hydrogen and tungsten hexachloride vapour in an electric oven. When the oven temperature and the pressure were low the crystal grew in such a way that it remained a single crystal up to 3 to 4 times the original diameter, the section perpendicular to the length sometimes showing hardly any trace of a junction with the original crystal; the section is bounded by a number of lines, generally curved and either concave or convex outwards, which in some cases meet in sharp corners, the number of these bounding lines, and therefore of the faces of the roughly prismatic crystal may be 8, 6, or 4 according to the relation between the crystal axis and the filament axis of the original crystal. The cultivated crystals, unlike the original filament on which they are grown, are brittle; but heating for a few minutes to about 2500° C. removes the brittleness, and increases the tensile strength from 40 kg. per sq. mm. to 80. That of the original filaments was about 120. No microscopic difference could be detected in the structure of the metal after annealing, and the crystal lattice as determined by the Laue X-ray method remained the same. This result is regarded as very remarkable. A single crystal filament could be used to grow a larger crystal, even when distorted by twisting it, winding it into a helix or drawing it into a fine wire. The paper contains several other interesting items with regard to crystal growth under these conditions. H. N. A.

991. *Changes in Zinc Crystals under Deformation.* **H. Mark, M. Polanyi,** and **E. Schmid.** (Zeits. f. Physik, 12. 1 and 2. pp. 58–116, 1922.)—The paper consists of three parts; the first deals with the general description of the phenomenon and the experimental methods. The necessity for pure metal, in order to produce ductile zinc wire, and the influence of impurities on the ductility were investigated. The second part deals with the geometrical and crystallographic significance of the surface extension, the change in extension and the bending slip. The third part contains a discussion of the relationship between the structure and the strength. The paper is not suitable for abstracting, and the original should be consulted for details. F. J. B.

992. *Changes in Zinc Crystals under Extension.* **H. Mark.** (Phys. Zeits. 23. pp. 523–526; Disc., 526, Nov. 15 and Dec. 1, 1922. Paper read at Deut. Physikertag., Leipzig, Sept., 1922.)—The paper is a brief account of the work of the author and M. Polanyi and E. Schmid, the full account of which is given in the paper referred to in the preceding abstract. F. J. B.

993. *The Equilibrium Diagram of the Copper-Zinc System.* **H. Imai.** (Tôhoku Univ., Sci. Reports, 11. pp. 313–332, Nov., 1922. Sixty-fifth Report from the Iron and Steel Research Inst. In English.)—Numerous investigations which have been made in the past have been concerned with the transformation of the β constituent in the equilibrium diagram of the copper-zinc system. The present paper deals with an investigation of the nature of this transformation by means of the electric resistance method; the solubility lines, and the solidus and liquidus of the system were similarly ascertained. The equilibrium diagram found nearly coincides with Shepherd's and Tafel's diagram. In connection with the transformation of the β constituent, a negative result was obtained for a eutectoid separation or an allotropic change. The electric resistance and X-ray analysis methods lead to the new result, *viz.* that the transformation point at 480° is the starting-point during cooling and the ending-point after heating, of a progressive change of non-allotropic nature, extending from a low temperature to 480°, which is similar to the A_2 transformation in iron. The γ constituent has also a transformation at 480°, and also another at 260°, of the same nature as that in the β constituent. Solubility lines have been determined in the field of α, β, and γ, at high temperatures. The freezing ranges have been determined also by the resistance method, and were found to be somewhat narrower in the composition of the β constituent than those previously determined by thermal analysis, especially in the composition of 60/40 brass, the freezing range approaching almost zero. The resistance composition curves at room temperature, and solidus and liquidus lines have also been obtained. The temperature, at which the δ constituent dissociates into a eutectoid mixture, has been determined to be 530°. The paper includes a number of tables, equilibrium curves, and temperature-resistance graphs. A. W. J.

994. *The Constitutional Diagram of the Iron-Carbon-Tungsten System.* **S. Ozawa.** (Tôhoku Univ., Sci. Reports, 11. pp. 333–350, Nov., 1922. Sixty-ninth Report from the Iron and Steel Research Inst. In English.)—This is an account of the determination of the constitutional diagram of alloys of wrought iron with a 99 % tungsten powder. A preliminary reference is made to the previous work and results of Honda, Murakami, Harkort, and Bornemann. The cooling curves were obtained by means of a platinum platinum-rhodium thermo-couple, but for the higher tungsten alloys a Leeds and Northrup optical pyrometer was used. The results obtained are given in the form of graphs and constitutional diagrams; tabular values and microphotographs are also included. The results obtained show that the temperature of crystallisation of the iron-tungsten alloys by the addition of tungsten is not so much affected as shown by Harkort's results. It is also concluded that the A_3 point rises with the increase of tungsten, but its intensity gradually diminishes. The A_3 point, 790° C., was not sensibly affected by the addition of tungsten. The investigation of the microstructure of the system leads to the same result as that of Honda and Murakami, and only one compound, namely Fe_2W, was found to exist between iron and tungsten. The results of a magnetic and microscopic investigation showed that the cementite and tungstide are mutually soluble to a certain concentration, and that in high carbon and tungsten steels, these solid solutions decompose, giving out tungsten carbide WC. The ternary eutectic point has been determined to be 1065° C., its composition being 15·0 % of tungsten, 3·6 % of carbon, and 81·4 % of iron. The binary eutectics of austenite-cementite and austenite-tungstide, which meet at the ternary eutectic point above stated, have been found by thermal analysis and from the microstructure. A. W. J.

995. *Binary Lead Alloys.* **J. Goebel.** (Zeits. f. Metallkunde, 14. pp. 357–366, Sept.; 388–394, Oct.; 425–432, Nov., and pp. 449–456, Dec., 1922.)—A complete series of determinations of the variations of physical properties, electrical conductivity, specific gravity, hardness of lead alloyed with varying proportions of bismuth, mercury, tin, cadmium, antimony, arsenic, magnesium, sodium. The results were correlated with the equilibrium diagrams of the various binary alloys, and the microstructure was examined in the case of the lead-sodium alloys. For the results the original paper must be consulted. F. J. B.

996. *Quenching of Steel Alloys.* **A. Portevin.** (Rev. de Mét. 19. pp. 717–740, Dec., 1922.)—A summary of a paper read by the author at the Liège Congress of June, 1922, containing a useful review of the present state of knowledge on the subject of heat treatment, (1) in general, (2) with special reference to steel, and (3) with reference to other alloys. J. L. H.

997. *The Statistical Basis of Chemical Thermodynamics.* **W. Schottky.** (Ann. d. Physik, 68. 6. pp. 481–544, Sept. 14, 1922.)—The scope and use of chemical statistics is first reviewed historically, examples being quoted from the work of Tetrode, Ehrenfest, etc. Section 1 then discusses the determination of chemical work by thermal measurements, shows the elimination of isothermal reversible chemical processes by theoretical deductions from chemical operations at $T = 0$, and criticises the Nernst theorem from the standpoint of its limitations in practice. Section 2 introduces the general scope and claims of chemical statistics, discusses chemically changed systems in the phase space, and investigates the statistics of incomplete equilibria. Theoretical or formal entropy and technical entropy are then distinguished, the former being only identified with the latter when changes via macroscopic variables can be introduced as reversible in a practical manner. Section 3 investigates the conditions for exchange of similar particles, the problem of reduced phase space, retarded reactions and boundaries. Results for short time intervals are derived, and the entropy expression resolved into its constituent terms. Section 4 investigates the case where the number of particles can fluctuate, and interprets the phase integrals as a sum of components.

H. H. Ho.

998. *Dissociation and Formation of Calcium Cyanamide.* **V. Ehrlich.** (Zeits. Elektrochem. 28. pp. 529–542, Dec. 1, 1922.)—The physical and chemical conditions which govern the formation and dissociation of calcium cyanamide (or "Kalkstickstoff") have been the subject of numerous investigations, both from the technical and scientific side, during the years 1906–1911. These have ranged themselves chiefly around the temperature of 1100° C. and with the effect of the addition of calcium carbide and calcium fluoride upon the course of the reactions. The investigation carried out by the author was undertaken in order to clear up some of the doubtful points that have resulted from the earlier work. The experimental part of this research was commenced in 1912 for the Bosnischer Elektricitäts A. G. Wien in the electrochemical laboratories of the Staats Gewerbe Schule Chem. Tech. Richtung Wien, and was completed during the war, in the research laboratory of the same Company in Oberwaltersdorf, near Wien. The summary of the research, as given by the author, at the end of a lengthy paper is as follows:

(1) The dissociation of "Kalkstickstoff" when exposed to temperatures over 1100° C. is not absolutely dependent upon the temperature; an observation which agrees with the results of investigations by Le Blanc and Eschmann, but not with those of Thompson and Lombard.

(2) Above 1200° C. sublimation of $CaCN_2$ commences, and this increases as the temperature rises to 1300° C. At the latter temperature, a formation of calcium carbide occurs, due to the reaction between the freed carbon and calcium, and to the action of the carbon monoxide gas upon some portion of the sublimated calcium cyanamide.

(3) Pure $CaCN_2$ sublimates at 1300° C. without previously melting; and an addition of 10 % CaO lowers the melting-point to 1200° C. An addition of 15 % $CaCl_2$ lowers it still further to 850°–900° C.

(4) The pure $CaCN_2$ when free from carbon, dissociates at 1000° C. with liberation of nitrogen, presumably according to the equation

$$\text{(A)}\quad CaC + N_2 \rightleftarrows CaCN_2$$

For the pure cyanamide, critical pressures can be determined which depend upon the temperature; and these constants are not affected materially by additions to the cyanamide; but above 1200° C. the sublimation of the cyanamide lowers the dissociation pressure.

(5) The dissociation of the pure $CaCN_2$ when free from carbon, occurs in the same range of temperature, but with smaller nitrogen pressure, as that of "Kalkstickstoff" which contains free carbon. The presence of the latter increases the dissociation pressure, apparently as a result of the reaction represented by

$$\text{(B)}\quad CaC_2 \rightleftarrows CaC + C.$$

This probably occurs under 1100° C. as a dissociation, and above 1100° C. as a synthetic process. It must therefore be regarded as a heterogeneous reaction, the course of which is determined by the surface tension of the solid phase.

(6) The "Kalkstickstoff" equation as usually written: $CaC_2 + N_2$

$= CaCN_2 + C$, must be regarded as made up of the two steps given in the equations A and B. It is improbable that there is a primary formation of cyanide.

(7) The heat of formation of the calcium cyanamide, according to equation A, calculated by the Nernst formula, is 61,400 calories; and the heat of formation of "Kalkstickstoff" is probably in the neighbourhood of this figure. J. B. C. K.

999. *Electromotive Behaviour of Aluminium.* (A rejoinder to the reply of A. Günther-Schulze.) **A. Smits.** (Zeits. Elektrochem. 28. pp. 543–545, Dec. 1, 1922.)—This note is to remove a certain misunderstanding which Günther-Schulze has apparently incurred in his criticism of the author's publication on the above subject [see Abstract 186 (1921)]. Günther-Schulze's statement that his theory remains uncontradicted has ignored Le Blanc's criticism after mutual discussion. The present author in dealing with the valve-like mechanism proposed by Günther-Schulze, points out that other active factors exist which control the former, and in this paper he considers the valve-like effect in connection with some experiments relating to polarisation phenomena at low electromotive forces, remarking that in the previous rejoinder he had intentionally omitted to mention the valve-effect. The hypothesis of an insulating oxide layer of molecular thickness is considered, and some of Günther-Schulze's criticisms not only shown to be erroneous, but his experimental results invalidated. The author, however, concludes that his own experimental data do not either support the presence or point to the absence of an oxide layer. Yet when Günther-Schulze states that for attaining contact between Al and Hg, the oxide layer must be broken, in this case such a layer does not arise. The discrepancy between the results obtained by the two investigators cannot be ascribed to the presence of traces of iron as Schulze suggests, since it is found that an oxide layer is unnecessary for the valve-effect. A reply is appended from **Günther-Schulze** in which he maintains his hypothesis of a continuous oxide layer of molecular thickness coating the aluminium, while he suspends further discussion until fresh experimental evidence is to hand. H. H. Ho.

1000. *The Salt Character of Sodium Ethyl. Indirect Electrolysis of Zinc Ethyl.* **F. Hein.** (Zeits. Elektrochem. 28. pp. 469–471, Nov. 1, 1922. Paper read at Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—The alkyl derivatives of strongly electropositive metals, the author considers, have the character of salts because these metals replace one another (Schlenk, 1917). Thus $2Na + Hg(C_2H_5)_2Hg \longrightarrow + 2Na . C_2H_5$, and this substitution takes place in accordance with the voltaic series. The sodium ethyl cannot be fused without decomposition, and is insoluble in most indifferent solvents; but it decomposes zinc ethyl only partially and forms with it a double compound $Na . C_2H_5, Zn(C_2H_5)_2$ (Wanklyn, 1858) which is soluble in zinc ethyl, and this solution conducts the current well and is easily electrolysed, while the zinc ethyl itself is almost a non-conductor. As the solution mentioned is spontaneously inflammable, the electrolysis is carried out in a nitrogen atmosphere; the products are zinc and ethane and ethylene (C_2H_6 and C_2H_4), not butane C_4H_{10}. The electrolysis proceeds as if zinc ethyl were alone present, and is thus an indirect electrolysis of zinc ethyl. H. B.

1001. *Determination of the Degree of Dissociation of an Electrolyte by the Study of its Conductivity.* **E. Cherbuliez.** (Soc. Phys. Hist. Nat. 39. pp. 155–157, Aug.–Dec., 1922. Suppt. to Arch. des Sciences, Nov.–Dec., 1922.)—Hitherto from the conductivity of an electrolyte in solution it has only been possible to determine the degree of its dissociation when the limiting molecular conductivity at complete dissociation, λ_∞, was known. Then the degree of dissociation is known from the equation:

$$\lambda = \alpha\lambda_\infty, \quad \alpha = \lambda/\lambda_\infty \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

where α = degree of dissociation as fraction of unity, λ = observed molecular conductivity for a given concentration, and λ_∞ = limiting molecular conductivity. For strong electrolytes λ_∞ may be determined by measurements of the conductivity of solutions more and more dilute, which allow of extrapolation for infinite dilution. Indirect methods are used for weak electrolytes. These obey the law of dilution. For a binary electrolyte the law of dilution has the form $K = \frac{\alpha^2}{\nu(1-\alpha)}$ where K = dissociation constant of the electrolyte, and ν = volume in litres containing 1 gramme-molecule of the electrolyte.

On taking the logarithm of this equation and then differentiating and transforming, finally the following equation is reached:

$$\alpha = \frac{1 - 2\tan\phi}{1 - \tan\phi}; \quad \tan\phi = \frac{d\log\lambda}{d\log\nu}.$$

From this by graphic representation of $\log\lambda$ as function of $\log\nu$, and drawing the tangent at a point α for this point may be obtained, and hence λ_∞. When the conductivity is known to be about 35 %, λ_∞ may be determined within some units per cent.

When λ is represented as a function of $\log\nu$, concave curves are obtained with feeble dissociation, convex with high dissociation. The point of inflexion is found to correspond with a dissociation of 58·6 % independently of the dissociation constant of the binary electrolyte, provided it obeys the law of dilution. It may be shown then that the tangent at the point of inflexion $d\lambda_i/d\log\nu_i$ enables the value of λ_∞ to be determined by the following equation:

$$\lambda_\infty = \frac{3 + 2\sqrt{2}}{\log 10} \cdot \frac{d\lambda_i}{d\log\nu_i} = 2{\cdot}531\,\frac{d\lambda_i}{d\log\nu_i}.$$

J. J. S.

1002. *Possibility of Variable Intermediate Stages in the Kolbe Reaction. Formation of Anodic Esters of Aromatic Acids.* **C. Schall.** (Zeits. Elektrochem. 28. pp. 506–511, Dec. 1, 1922.)—In the Kolbe reaction the carboxyl group CO . OH is directly introduced into phenols by heating an alkali phenolate in a current of CO_2; a modification of the reaction is technically applied, *e.g.* in the manufacture of salicylic acid. When a salt of a monocarbonic acid with a base of constant valency is electrolysed, the Kolbe reaction should take place in one stage; when the base of variable valency is used, intermediate stages are possible; the diacetates of zinc and of lead represent the two types. The author investigates the intermediate stages of the electrolyses of fused lead diacetate (studied by J. Petersen) and of manganous dibenzoate in fused dry benzoic acid; further, the electrolysis of potassium benzoate in fused aqueous benzoic acid by means of a silver anode, which yields the ester phenyl benzoate as anodic product. Intermediate variable stages of the reaction appear to be possible even when the base has constant valency. H. B.

1003. *Lead Tetra-Acetate and Tetrapropionate and Silver Diacetate as Anode Products.* **C. Schall** and **W. Melzer.** (Zeits. Elektrochem. 28. pp. 474–477, Nov. 1, 1922. Paper read before the Deut. Bunsen Gesell., Leipzig, Sept., 1922.)—The electrolytic lead tetra-acetate of Elbs (1896) was not pure. The electrolysis of pure lead diacetate, dissolved in 99·7% acetic acid, to which some dry sodium acetate is added, gives a fair yield of the pure tetra-acetate; the sodium salt increases the conductivity of the solution and the solubility of the product. Closed cells with clay diaphragms and platinum anodes are used; troublesome by-products are the lead trees and PbO_2. The preparation of the lead propionate is conducted in a similar way; the yield is very small. Still smaller is the yield of silver diacetate when silver acetate, to which sodium acetate is again added, is electrolysed with platinum anodes; the silver diacetate is the first organic salt of divalent silver prepared, but the purity of the product seems doubtful. H. B.

1004. *Diffusion of Kathode Hydrogen through Iron and Platinum.* **M. Bodenstein.** (Zeits. Elektrochem. 28. pp. 517–526, Dec. 1, 1922.)—The kathode employed was in most cases a hollow body made of iron, with an attached capillary tube, which carried the hydrogen passing inwards through the walls to a measuring vessel. The hollow space inside the kathode was filled as completely as possible with a mass of iron, so that the gas space was very small. The kathode voltage was measured with a capillary electrometer, a correction being made for the diminution of the number of H ions in the electrolyte near the kathode caused by the current. The measurements proved difficult, as the iron surface altered considerably in the course of an experiment. Tiny cavities in the iron got filled with hydrogen at high pressure (20 atmospheres pressure was observed in the interior of the iron by Bellati and Lussana); this often burst through the iron, and the kathode was gradually destroyed. Tafel's theory supposes that the H atoms produced on the kathode pile up on the surface, raise its potential, and have a strong tendency to diffuse through the metal. Möller on the other hand leaves the question of the form of the hydrogen on one side; but assumes that, in consequence of the electrostatic forces and molecular attraction, the H layer is under a very high pressure. This pressure is supposed to raise the potential of the kathode, and to drive the hydrogen through the metal. Both theories lead to the formula $\log D = \epsilon a/0\cdot61\,a + \epsilon/0\cdot057$; where D is the diffusion constant, ϵ the difference of potential between the solution and the electrode, and a is a constant. Measurements showed that the denominator was much larger than 0·057; values between 0·111 and 0·9 being obtained. The conclusion is that the voltage is the sum of two parts; the polarisation voltage ϵ_1 given by the above equation and that required to overcome the resistance of a surface layer, $\epsilon_2 = mi$, where i is the current. Taking $m = 0\cdot05$ and $a = -5\cdot811$, values of D which agreed with the observations were obtained. Experiments were carried out to determine whether the hydrogen passed into the interior space wholly or partly in the atomic state; but they seem to prove that the atoms unite to molecules when they pass out of the metal. It is estimated that in the outer portions of the kathode there must be at least 7 atoms of H for every atom of Fe. The relation between the diffusion constant and the current I was found to be $D = n\sqrt{I}$, which agrees with that deduced from Tafel's theory. H. N. A.

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